POWER

Vol. 34 NEW YORK, OCTOBER 31, 1911 No. 18

THIS man is a steam fitter. His standard wages in New York are $5.50 per day. He works eight hours and is careful not to do too much in that time and thus keep some other steam fitter out of a job.

The man who is superintending the steam fitter's work is an engineer.

He has charge of the engines and boilers, the electric generators and motors, the pumps and heaters and piping and radiators and elevators of a large building.

A trained mechanic, he knows more about steam fitting than the man who is working for him, and is, besides, an electrician, understands the intricate processes of combustion, knows how to set valves, measure horsepower, test boilers and keep machinery up to its work, detect incipient failure and foresee and obviate shutdowns and accidents.

He directs the activities of many men. The difference between competency and incompetency on his part may amount to thousands of dollars a year in the cost of running the plant.

Negligence or failure may result in expensive and annoying interruptions or even in serious disaster. He works 12 or more hours a day regularly, Sundays and holidays usually, and many evenings.

And for this he draws three or four dollars a day!

Why?

How much do you, Mr. Employer, pay your engineer?

Put your wrench down lower and support that under pipe!

How do his attainments and responsibilities and hours and wages compare with those of the responsible heads of other departments of your business?

Why do you pay him less than you do the pipe fitter who works under him?

Because you cannot get a pipe fitter for less!

And you cannot get a pipe fitter for less because the pipe fitters have gotten together and agreed not to work for less.

On the other hand, the engineers, recognizing themselves as in the executive class. have been trying for the past 30 years to improve their condition by increasing their efficiency and their knowledge of their business.

Their best supported organizations discountenance strikes, and tolerate no interference between employer and employee.

They seek to educate and improve their members in the faith that greater ability and better service will win the recognition which they deserve.

Do you, Mr. Broadminded Employer, who see further than the edge of the payroll, want to see this policy win, this faith fulfilled, or do you want to drive the engineer from his present motto,

TO EARN MORE,
LEARN MORE,

to the more trenchant slogan,

TO GET WHAT YOU EARN, ORGANIZE!

New Pumping Station for London

By J. B. Van Brussel

The Walton pumping station pumps water from the Thames to the Walton storage reservoirs from which it flows by gravity to the filters.

A difference in level of 43 feet between the storage reservoirs and the filter beds is made use of in water turbines for pumping additional water into the reservoirs and thus supplementing the work of the main pumping engines.

The total capacity is 130 million gallons per 24 hours.

A notable addition to London's waterworks system is the new Walton pumping station which has recently been placed in service. This station is located a few hundred yards from the south bank of the Thames at West Molesey and supplies several reservoirs of the London Metropolitan Water Board.

As shown in Fig. 1, there are three intake tunnels from the river, running under the towing path, and discharging into an open concrete-lined canal (see Fig. 2), the latter having a length of 1450 feet and terminating at the pumping station. Each of the intake tunnels is fitted with a hand-operated sluice gate which gives access to a screen chamber containing stout iron screens to prevent any drift matter from entering the intake.

The discharge side of all the pumps is connected to two 54-inch mains running under the entire length of the pump room, and by an arrangement of sluice gates they may be supplied separately or together by any or all of the pumps. These mains lead direct to the two Walton reservoirs and further connect with the Island Barn reservoir, nearly two miles distant. From the Walton reservoirs, which are 43 feet above the Thames river, two 48-inch mains run to the south bank of the river; here they join a tunnel under the river and from the north bank continue on to the reservoirs and filter beds at Hampton. The latter are at about the same level as the river.

When laying out the system it was decided to make use of this difference in level between the Walton reservoirs and those at Hampton; consequently, the pumping machinery at the Walton station is in two groups. The river water is first pumped into the reservoirs by four duplicate units, each consisting of a 14, 23 and 38 by 30-inch vertical triple-expansion condensing engine running at 150 revolutions per minute and coupled direct to a two-stage centrifugal pump capable of delivering 25 million gallons of water per 24 hours against a total head of 64 feet.

The other pumping units are of an entirely different character and consist of three centrifugal pumps, each driven by a twin horizontal mixed-flow water turbine utilizing the energy of flow from the Walton reservoirs to the Hampton filters. These are each capable of delivering 10 million gallons of water per 24 hours against a head of 64 feet and are placed in parallel with the main pumping engines. By this arrangement it is possible to recover approximately one-third of the power originally employed in pumping into the reservoirs; that is, the main pumping engines are required to operate only two-thirds of the time which would otherwise have been necessary. It is estimated that a saving of 10 to 12 tons of coal per day under average pumping conditions is thus effected. Both the engine- and turbine-driven units are shown in Fig. 3.

Steam for the main pumping engines is furnished at 200 pounds and from 120

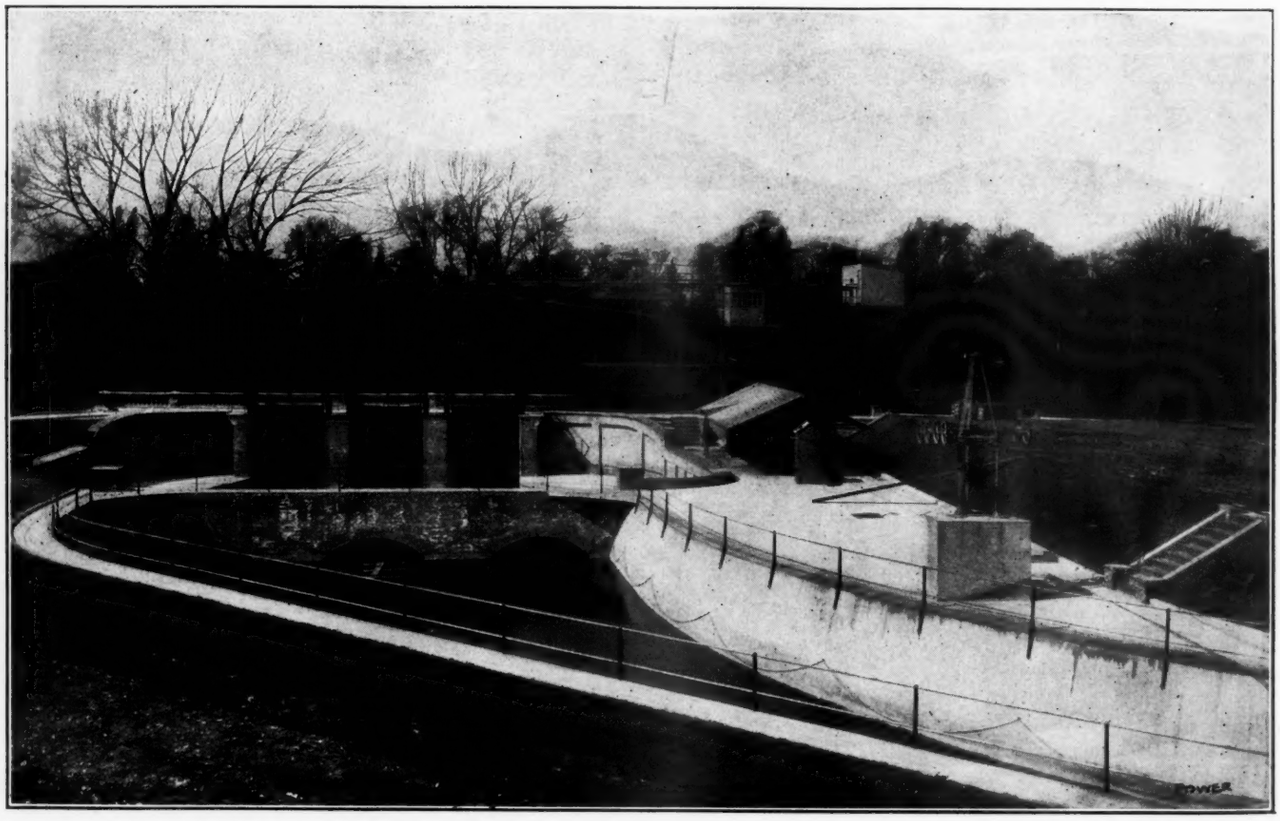


FIG. 1. INTAKE TUNNEL AND GATES

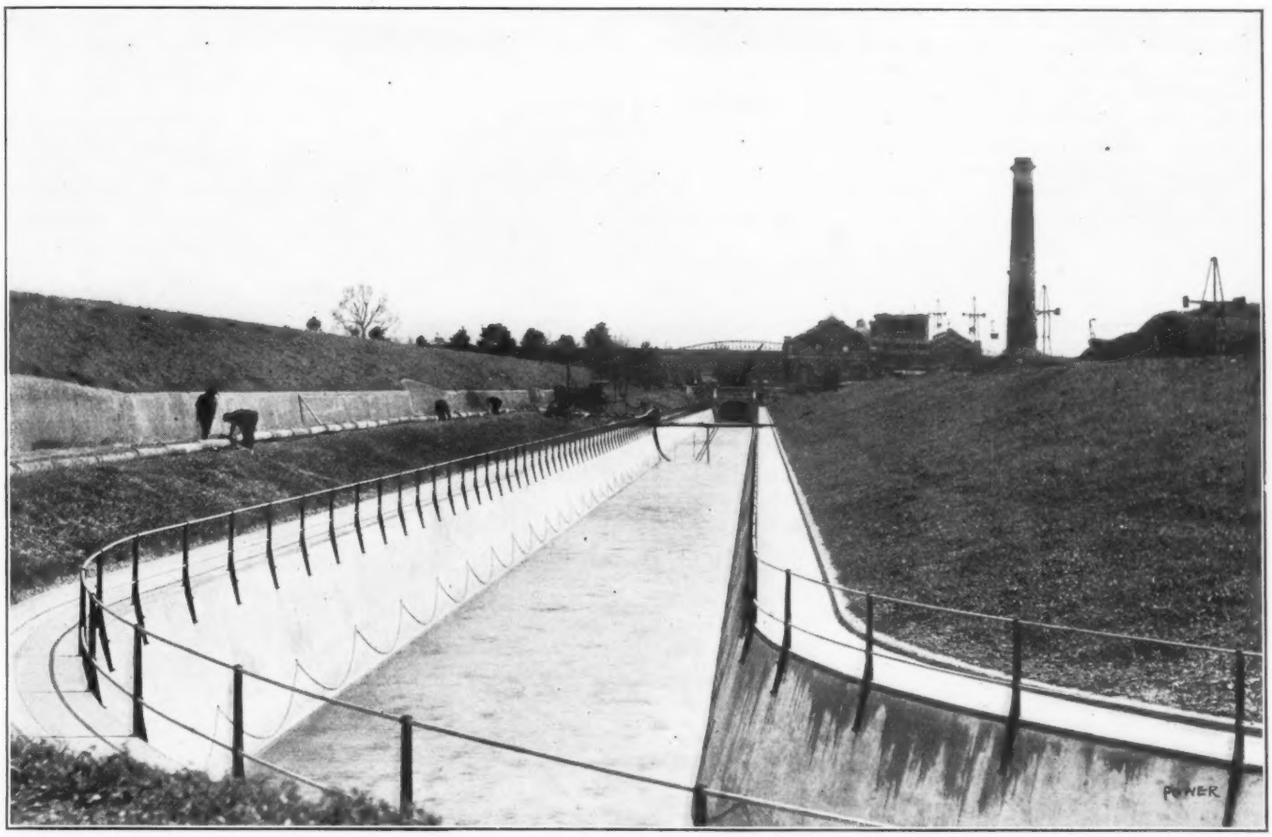


FIG. 2. INTAKE CANAL FROM RIVER TO PUMPING STATION

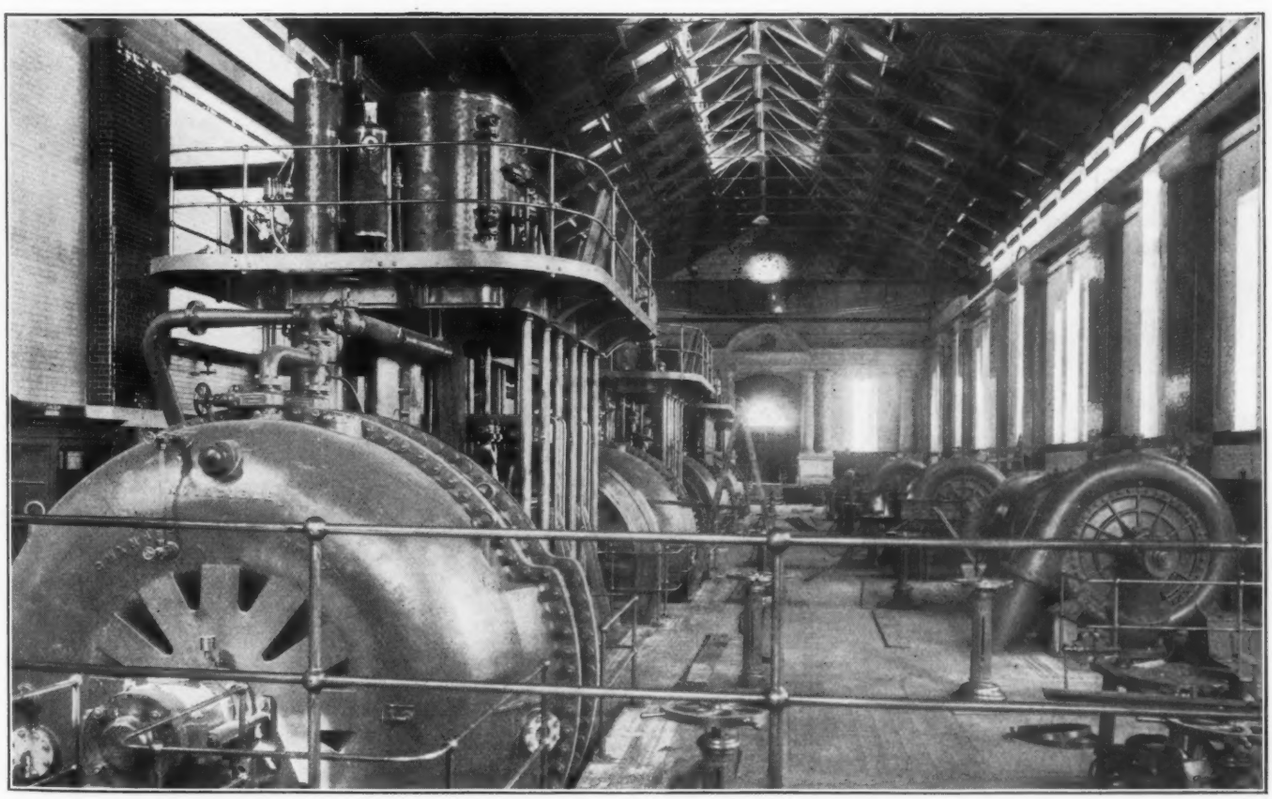


FIG. 3. ENGINE ROOM, SHOWING BOTH STEAM-DRIVEN AND WATER-DRIVEN UNITS

to 150 degrees superheat by ten Babcock & Wilcox boilers arranged in five batteries of two each, as may be seen from the general plan, Fig. 5. These boilers each have 1800 square feet of effective heating surface and 37.4 square feet of grate surface. They are provided with chain-grate stokers fed from an overhead bunker. By reference to Fig. 6, it will be noted that the roof of the boiler house is designed so as to admit sufficient light over the boilers in spite of the presence of overhead bunkers.

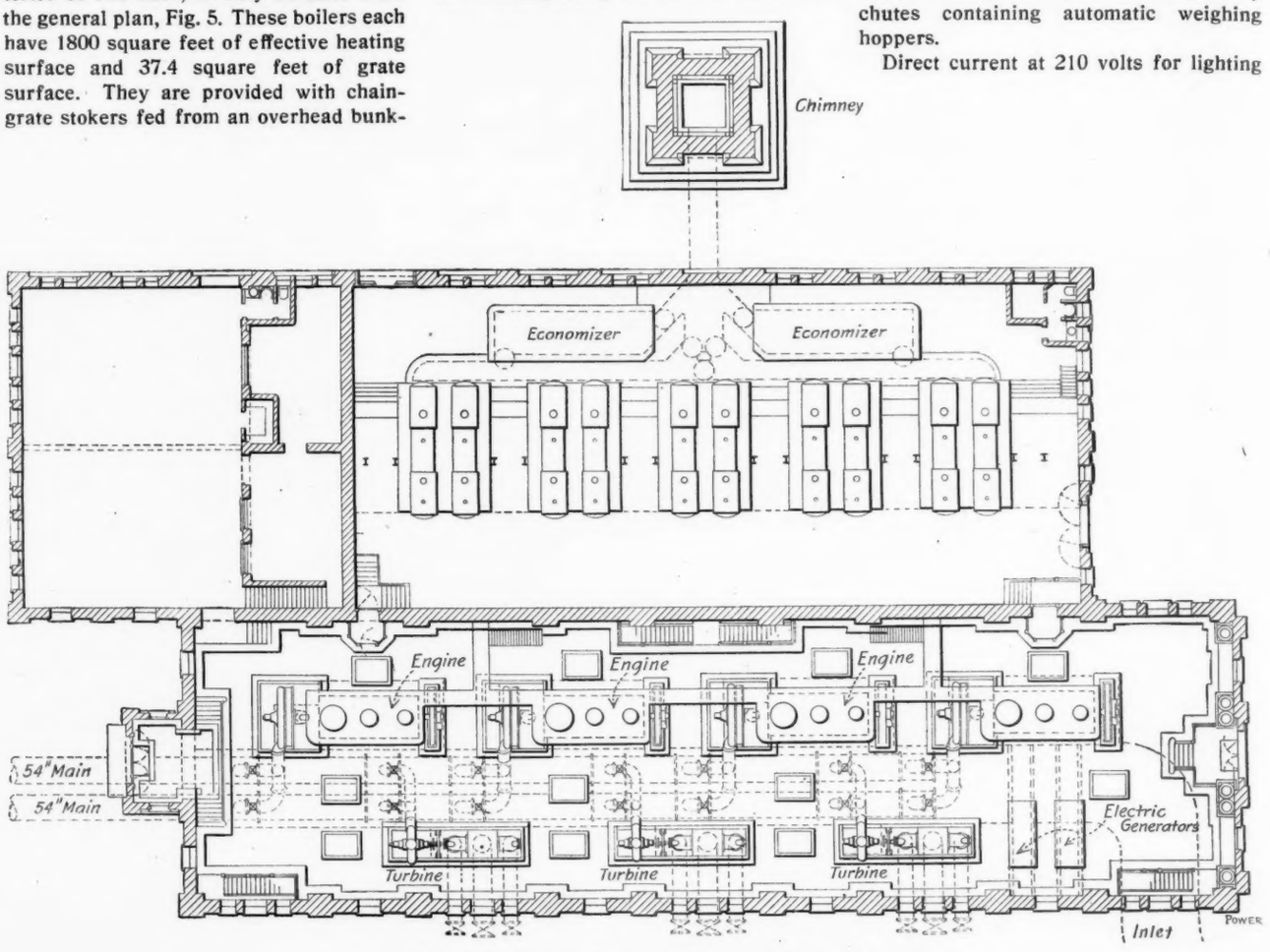


FIG. 5. GENERAL PLAN OF PUMPING STATION

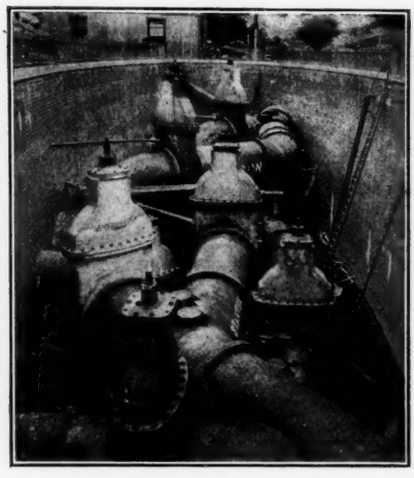


FIG. 4. PIPE PIT

The method of handling the fuel at this plant is novel. Coal is brought up the river in barges from which it is taken by an electrically operated traveling crane (see Fig. 1) carrying a grab bucket. After transporting the coal a short distance from the river, the crane deposits it into a hopper erected over one end of a continuous aërial conveyer, shown in Fig. 2, which carries the coal in skips to the overhead bunker in the boiler house. From here it is fed to the stokers by chutes containing automatic weighing hoppers.

Direct current at 210 volts for lighting and operating the coaling crane, conveyer and large valves is furnished by two steam-engine-driven generating sets.

FIG. 6. BOILER ROOM

Vibrations of the Indicator Pencil

By J. W. Taylor

An analysis of the causes of the jagged expansion line of an indicator diagram and the effect upon indicated results.

The diagrams shown in Fig. 1 were recently published for criticism in POWER with especial reference to the expansion line. They are evidently taken from a high-speed engine with an exceedingly rapid cutoff. They are excellent diagrams and the engine from which they are taken is without doubt economical in the use of steam. However, as no accompanying data were given, the discussion here will be confined only to the "jagged expansion line" and in but a general way.

Too much should not be expected of the indicator; it is a clever piece of mechanism and a very useful instrument, but its every whim and fancy must be well understood to correctly interpret its records. An indicator diagram at best cannot be relied upon closer than 3 per cent. Engineers are too prone to be

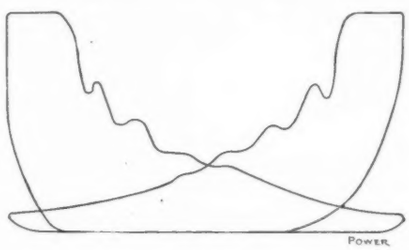


FIG. 1.

fussy over an ideally formed diagram even to the sacrifice of smooth operation and economy of the coal pile. The diagram, it must be remembered, is a means and not an end.

Irregularities in the diagrams can be caused by leakage of steam into or from the cylinder, but such distortions in no-wise approach a series of waves. When such leakage occurs on the expansion line the general trend of the line is decidedly altered, and it will be noticed in the figure that this is not the case, for the expansion here is normal and continuous.

The jagged expansion line is due to the vibrations of the indicator arm, the frequency of the sinuous waves being from 20 to 50 times the impressed frequency of the engine vibrations. The arm is the only part of the indicator, subject to vibration, which has anywhere near this frequency.

The diagram in Fig. 2 is taken from Fig. 1 with the crank circles added. It will be noticed that the projection of the waves upon the circle subtend equal arcs showing a regularity of period characteristic of a vibrating body. The arcs subtended in this case are about 12 degrees. Assuming an engine speed of 150 revolutions per minute, or 2.5 per second, would give

$$\frac{2.5 \times 360}{12} = 75 \text{ oscillations per second}$$

Fig. 3 shows the formation of such an expansion line by the combination of

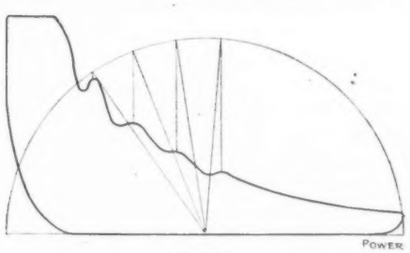


FIG. 2.

normal expansion and vibration curves, considerably enlarged for clearness. The sinuous vibration curve *A* shows a gradually decreasing wave amplitude such as occurs when the cause of disturbance is removed, the expansion curve *B* being taken from the same point of cutoff as in Fig. 1. The forward movement of the vibrations of the indicator arm, the frequency of the sinuous waves being from 20 to 50 times the impressed frequency of the engine vibrations. The arm is the only part of the indicator, subject to vibration, which has anywhere near this frequency. The mode of combination is quite evident from the illustration and the familiar appearance of the resultant curve *C* is conclusive.

Occasionally diagrams will show several waves following admission, and if these are projected to the crank circle, as in Fig. 2, they will show the same period of vibration as occurs following cutoff. Generally, however, there is but a partial vibration and that but indistinctly shown if at all. That a pencil overruns its mark is due to the inertia of the reciprocating parts, and it leaves but a rudimentary vibration or "horn," as it is usually called. Still it is possible for several vibrations to be penciled at this position without showing otherwise than as a single line, for the crank can swing here through a decided angle without moving the drum perceptibly.

The vibrations of the arm are set in motion by a sharp blow produced by a rapid change of pressure; pressure from a quick early cutoff drops very rapidly.

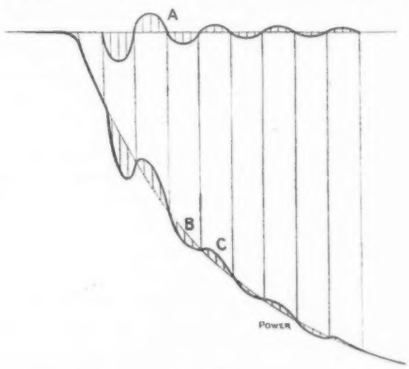


FIG. 3.

The pressure at compression rises very rapidly also, but the continually lowering expansion line is more favorable to the existence of vibrations than is the constant admission line. It appears from the usual diagram that the pressure changes from the end of compression to admission are even greater than those at cutoff. They are not necessarily so, however, for the reason previously cited.

If a diagram is taken with the drum cord driven by an eccentric it will be seen that this rise of pressure is surprisingly gradual in the majority of cases. Such a diagram, called an "eccentric diagram," is an excellent means of analyzing the changes taking place at points

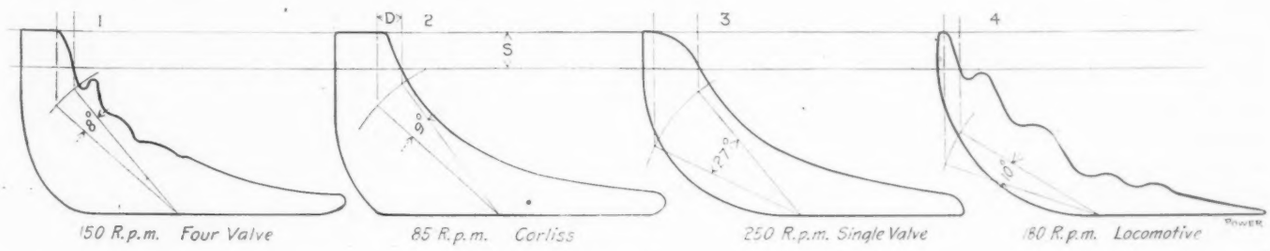


FIG. 4.

which are but poorly brought out on the usual diagram.

In Fig. 4 is brought out clearly the type of engine upon whose diagrams the vibrations of the indicator arm are apt to appear, and these are all at about the same point of cutoff. The excessive wire-drawing in the locomotive diagram has the same effect upon the indicator arm as does the cutoff in the four-valve engine. The speed of cutoff at early points in many four-valve engines is even more rapid than in the Corliss engine. While the pencil drops through the distance *S* the piston travels the distance *D*, a projection of which gives the corresponding angle passed through by the crank. From this angle and the speed of the engine the time occupied by the pencil in dropping the distance *S* is readily obtained. This time is equal to the angle passed through by the crank divided by the product of 360 and the revolutions per second. In diagram No. 1 this time is 0.0085 second; in No. 2, 0.0200 second; in No. 3, 0.0225 second; and in No. 4, 0.0093 second. From this it is evident that the time occupied in dropping the distance *S* is over twice as great in Nos. 2 and 3 as in Nos. 1 and 4. As the energy of a moving mass is proportional to the square of its velocity, the disturbing effect set up in the arm, while whipping through this distance, is over 5½ times as great in the first and fourth diagrams as in the second and third.

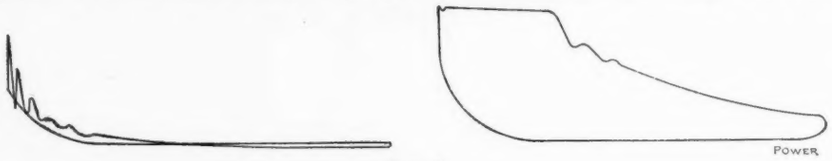


FIG. 5.

The frequency of vibration depends upon the length and section of the arm and the weight of the pencil holder. The amplitude also depends upon these factors and in addition upon the severity of the shock. This accounts for the change in appearance of these vibrations with the change in cutoff. Though the intensity, location and number vary from zero to maximum cutoff, the frequency is constant. At the later points of cutoff the pressure falls off much more gradually during expansion than at the early points and in all single- and four-valve engines the later cutoff is much slower in action than the early cutoff, which lessens considerably the whipping effect of the indicator arm.

The initial amplitude of the wave in Fig. 1 is about 9/32 inch, which gives a deflection of 9/64 inch each side of the normal. A very slight pressure on the end of the arm will easily give this deflection and a sharp whip of the arm will readily duplicate it.

With an engine giving this wavy diagram, a very interesting experiment can be performed by turning the indicator arm. The diagrams in Figs. 5 and 6 are taken from a 20x20-inch four-valve engine running at 170 revolutions per minute. Each figure shows a friction and a load diagram. All were taken within a few minutes of each other, with the conditions, as far as the engine was concerned, as nearly alike as possible in the two figures. Those in Fig. 5 were taken with the regular indicator arm, and the waves show a vibration frequency of about 108 oscillations per second. In Fig. 6 the arm was turned down to about one-half the pitch by the addition of a piece of lead near the pencil. The waves in this case represent about 56 oscillations and the additional weight not only reduced the number of vibrations per second but very naturally increased the amplitude and wave length. The friction diagram here is a striking example of arm vibrations. The steam distribution in these two cases is precisely the same regardless of the appearance of the diagrams, for certainly the addition of a little lead to the indicator has no influence upon the steam consumption of the engines, nor would an indicator with a stiffer arm giving a more nearly ideal diagram alter the case at all.

It will be noticed in Fig. 3 that the waves subtract from the normal expansion line somewhat more, in subtended area, than they add. However, as this scalloped edge is but a small fraction of the entire diagram area, the error thus introduced is small; and having a negative sign it is on the safe side and can well be neglected. Even with a friction diagram as excessive as that of Fig. 5, the error introduced will be well within the inherent error of the indicator. This means that the actual mean effective pressure of the cylinder can be obtained by following the jagged expansion line.

These sinuous lines are very frequently observed. They appear on the diagrams of a number of both American and European engines. With such diagrams the actual steam changes can be closely followed by drawing a median line through the waves.

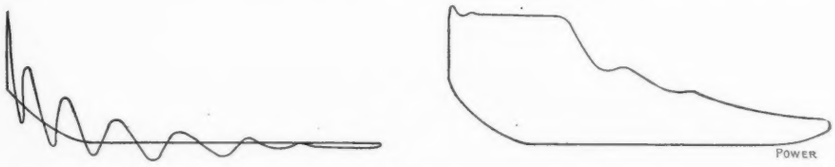
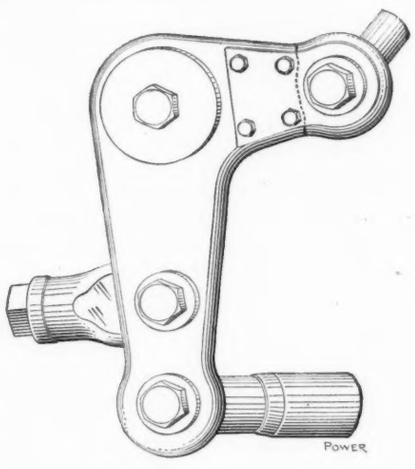


FIG. 6.

Bell Crank Repair

The bell crank on the head-end exhaust valve of the low-pressure cylinder of a 500-horsepower cross-compound Corliss engine broke one morning while the engine was running under apparently normal conditions. The fracture occurred as shown in the illustration and the cause is not known.

As it was necessary to use the engine day and night a temporary repair was made which proved so successful that the repaired bell crank will doubtless be left in place as long as it will safely operate. A piece of ⅝-inch steel plate was shaped to fit the inside of the horizontal arm of the bell crank, and four holes were drilled in one end and one hole in the other. A stud was placed through the single hole for the valve-arm connection which secured that portion of the fractured bell crank to the reinforcing plate when the stud nut was turned up tight. Four holes were then drilled in the stub end of the crank and tapped to correspond to the four holes in the reinforcing plate; four tap bolts were used to secure the plate to the arm.



REPAIRED BELL CRANK

A valve should be placed as close to a pump as possible, in order to allow cutting the pump out of service without disturbing the pipe or interfering with other methods of feeding. There should be three valves in the pipe leading from the pump to the boiler, one between the boiler and the check valve; one convenient to the boiler front to be used in the feed regulation; and one close to the pump.—*Ex.*

Limitations of the Rope Drive

By Walter B. Snow

Inquiries among manufacturers, mill owners and consulting engineers brought forth diversified opinions regarding the relative merits of rope-drive, belt-drive and electrical transmission.

The conclusion to be drawn from the majority of the replies indicates that rope transmission has a good field where large powers are to be transmitted and the distances lie between 75 and 150 feet.

The adaptability of rope for almost every condition of power transmission has been so ardently urged by some and so vehemently condemned by others that one may well ask whether there is really any place in which it is justifiable to use the rope drive. In an effort to clear away some of the confusion and to set forth, if possible, the limitations to the efficient use of rope transmission, inquiry was recently made in a variety of industries and among a considerable number of designing engineers. Each was asked for an opinion as to whether the use of rope was growing in relation to belts, and when and why rope was to be considered preferable to belts.

The replies to these inquiries may be roughly grouped into the following classes: Twenty-three from textile manufacturers, twenty from paper manufacturers, five from workers of metal, principally machinery manufacturers; twelve from designing and consulting engineers, and three from diversified industries. The total number of replies represents only 63 per cent. of the inquiries sent out. The fact that the replies received from the various classes is not proportional to the inquiries sent to each suggests that where the percentage of replies is low there has been comparatively little experience in the use of rope transmission. The letters present such a wide diversity of opinions that a casual reading leaves one as much confused as at the beginning. But a careful analysis and classification of all of the letters disclose some interesting and instructive groupings of opinions, and reveal more or less logical reasons for the differences in opinions.

First of all, it appears that all except the most violent opponents concede to rope a field of somewhat elastic proportions in which it is recognized to be better than belts, gears or chains. In the second place, it is noticeable that there is a relatively sharp distinction between the attitude of the consulting or designing engineer and that of the individual who is in daily touch with the operation of a rope drive. Doubtless because the former views the subject in a broader and more critical way, he sees imperfections which do not appeal to his less technical brother. In fact, the man on the job seems to encounter but a small proportion of the troubles set forth by the man who makes the plans. From this it might be assumed that the imperfections of the rope drive are largely theoretical and that they have to do with efficiency rather than with mere ability to transmit power.

Because the rope has been so generally regarded as always the rival of the belt as a medium for transmitting power between rotating members, the real fact that each has its distinct field has been somewhat overlooked. True it is that these fields overlap in many instances, but this only emphasizes the point that there are extremes in which only one of the two means of transmission ever rightly belongs.

It was freely predicted not long since that the advent of the individual motor drive would mark the passing of both belts and ropes from the power-transmission field. Indeed, many shops and mills were changed over to accommodate the all-conquering motor. But wider experience with the electric drive has demonstrated that it, too, is circumscribed in scope and cannot be specified offhand as the best. Its application is undoubtedly widespread and some remarkable economies have been effected by its use in places for which it is peculiarly fitted. The situation with regard to the direct drive was clearly presented by F. W. Taylor in his address as president of the American Society of Mechanical Engineers, in which he said:

"Of late years there has been what may almost be termed a blind rush on the part of those who have wished to increase the efficiency of their shops, toward driving each individual machine with an independent motor. I am firmly convinced, through large personal observation in many shops and through having systematized two electrical shops, that in perhaps three cases out of four a properly designed belt drive is preferable for machine tools."

Here the motor competes only with the belt, for the power to be transmitted is small. With increase in load and distance the field for the rope broadens, the opportunity for efficient use of belts is practically removed and electricity remains as the only rival. But except where the mill is electrically operated throughout, the main drives still fall to the lot of the rope.

As between the two systems of rope drive, American and English, opinion seems to lean toward the use of the English system of a multiplicity of individual loops for heavy transmission, as against the American method of employing one long rope looped again and again over the sheaves and then carried over a tension sheave for lighter and especially complicated drives. The essential advantage of the former and older method is that the breaking of a rope will not cripple the drive, the remaining ropes dividing the work of the broken member among them. In the American system it is claimed that equal tension is obtained in each loop and therefore perfect distribution of the power is transmitted along the loops. All the loops being equally loaded, the possibilities of a break are greatly reduced, and it is maintained that much longer life is assured for the rope as well as greater transmitting efficiency due to the steady tension.

The variety of existing opinions regarding the use of rope for transmission which was revealed by this investigation cannot be better displayed than by quotations from some of the letters received. The superintendent of a large paper mill writes:

"We use but one rope drive in this mill for the transmission of about 300 horsepower. We would like, however, to have many more rope drives if we could induce their further adoption. We believe that the use of rope transmission is increasing and our experience is that the rope transmission is receiving more attention today than it has ever done. Part of this may be due to the greatly increased cost of rubber and leather belting and to the usually unsatisfactory results obtained by the use of cotton belting on account of its inferior tractive power. The first cost in connection with the adoption of the rope is lower as compared with belts and the subsequent upkeep is smaller and the results obtained where the rope drive is adequate for the services put upon it are much better than those obtained with belts.

"While much of the foregoing consists of merely bald assertions, they are the results of hard practical experience. At the present time we are installing considerable new machinery in one part of our mill and have arranged to use rope drives instead of belts in a place and for a service where rope has never been used before. We think so well of rope drives that we are contemplating using

them wherever possible in new installation in the future."

In distinct contradiction to the preceding, although qualified by limitations, is this statement of a well known firm of consulting engineers:

"We do not consider rope preferable to belts. At best, rope transmission is only to be used in exceptional cases. For indoor work, such as the driving of machine tools, transmission of power from line shaft to countershaft, and even from the engine to the jack shaft, rope transmission at no time has been and is not now a serious rival of belts. The only cases in which rope can be advantageously used is where power is to be transmitted, say more than 75 feet and less than 150 feet. For greater distances it is probable that electric transmission would be the cheapest and best. For shorter distances than 50 feet the use of belts would be preferable."

Another paper manufacturer presents a case for the exclusive use of rope in these words:

"We use rope drives for several purposes. The largest of these is used for driving a 600-kilowatt generator, and has proved very satisfactory in every case. This is an instance where it would be practically impossible to use belts as the generator is connected direct to two waterwheels. We have several other rope drives for the transmission of power to a point too far from the source of power to be able to use any other method than electrical transmission.

"The tendency seems to be to use rope in preference to belt wherever the horsepower to be transmitted is large and where there is ample room for sheaves on the driven machinery."

In contrast is this statement from a textile manufacturer:

"We are not using rope drive. We did use this system in our old mill, but had so much trouble with irregularity of the English system of rope driving after the ropes began to wear out and new ones had to be put on, that we abandoned the rope system, and have substituted belt drive instead. From our experience we consider belt drive preferable, although it costs a little more in the first place. Rope driving, according to our experience, runs fine for a few years, or until the ropes begin to give out, when everlasting trouble commences unless the mill substitutes a whole new system for every individual drive. New ropes will not work well together with old ropes which have worn down to a smaller diameter."

A firm of consulting engineers summarizes its opinion thus:

"In our opinion the use of ropes is not growing. It is also our opinion that the use of belts for transmitting power is decreasing. While motors are not universally adaptable for power transmission, there are many points in their favor in such plants as we have to do with and we believe their use is increasing, with a consequent decrease in the use of belts and ropes. We have found it expedient to use ropes instead of belts for transmitting power from waterwheels and in some other cases where dampness would prevent the satisfactory use of leather belts."

Some of the reasons for these wide differences in opinion are to be found in the following somewhat explanatory letter from an engineer noted for his conservatism:

"So far as my observation goes, I should say that with the introduction and extension of the use of electric transmission, the use of rope transmission would diminish at a more rapid rate than would the use of belts. The reason for this is that ropes have been used very largely for main drives from engines, and in nearly all cases the counterdrives have been belts. With the use of electric transmission, the main drives are done away with, but the drives from the motors and the counterdrives remain as formerly. "I believe that rope transmission is preferable to belts sometimes where large amounts of power must be transmitted, such as from large engines or to head shafts in a mill. Also, the use of ropes will avoid the extremely wide belt wheels. Furthermore, in places where power must be transmitted mechanically from one building to another and around corners, ropes are preferable to belts. Electrical transmission enables the elimination of these awkward drives."

Manifestly, the limitations of the rope drive are set by those of the belt, for electric transmission may supplant either. Within the field of efficient operation of the belt the rope is a poor rival, but beyond the limits of practicable belt lengths or widths the rope finds no superior; here it reigns supreme. Such is the evident consensus of opinion.

Temperature Expansion Diagram

By W. Vincent Treeby

The accompanying diagram shows the amount of linear expansion for copper, mild steel and cast iron. It should be useful to designers in laying out steam piping and similar work where the material is affected by changes of temperature and provision must be made for expansion to take place.

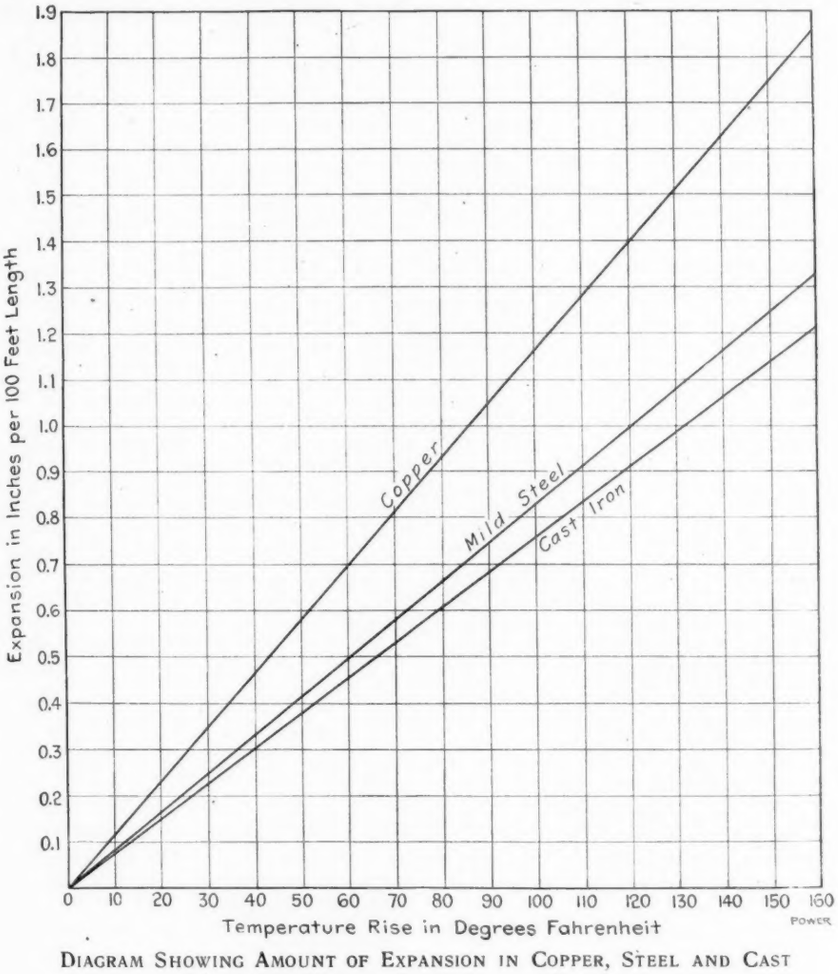


Diagram Showing Amount of Expansion in Copper, Steel and Cast Iron for Various Temperature Changes

Efficiency of Reciprocating Engines

By K. Heilmann

Performance of locomobile engines, the influence of primary and secondary superheating and of vacuum upon the steam consumption; also a study of the heat losses in the cylinder.

*Extracted and translated by W. F. Monaghan from a paper read before various local branches of the Vereins Deutscher Ingenieure by K. Heilman, who is chief engineer of the R. Wolf establishment at Magdeburg, Germany.

In the development of the reciprocating steam engine there are to be noted the gradual improvements such as increasing steam pressure and the use of more perfect expansion gear; also, the more rapid advancement resulting from compounding and condensing and particularly superheating.

Table I shows the effect of vacuum on the steam and heat consumptions in a locomobile reciprocating engine with an initial pressure of 220 pounds, a terminal pressure of 8.8 pounds and an initial temperature of 662 degrees Fahrenheit.

TABLE 1. INFLUENCE OF VACUUM ON STEAM AND HEAT CONSUMPTIONS

Temperature in the Condenser, Degrees Fahrenheit	Pressure in the Condenser, Pounds per Square Inch	Vacuum, Inches of Mercury	Steam Consumption, Pounds per Horsepower-hour	Heat Consumption Referred to the Temperature in the Condenser, B.t.u. per Horsepower-hour
158	4.66	20.2	8.00	8650
140	3.00	24.0	7.71	8490
122	1.84	26.2	7.51	8409
109	1.10	27.8	7.38	8389
85	0.63	28.7	7.31	8429
68	0.37	28.9	7.27	8449

ciency.* The line of this latter efficiency, for initial superheating, rises quickly to 750 degrees Fahrenheit and from 120 degrees of intermediate superheating it rises rapidly to about 660, to follow thereafter a flatter curve. With these temperatures the steam leaves the low-pressure cylinder in a dry, saturated condition. Up to the highest temperatures the curves of steam and heat consumption show a falling tendency and that of thermodynamic efficiency a rising one.

The convergence of the Rankine cycle curves, with and without secondary superheating, indicates that the value of such superheating with moderate initial superheating is not insignificant; while, on the contrary, with high initial superheating it constantly diminishes. The saving of steam through an intermediate superheating of 120 degrees with 390 degrees of initial superheat amounts to about 10 per cent.; with 570 degrees about 8 per cent.; with 750 degrees about 5.5 per cent., and with 930 degrees about 3.5 per cent., and because of the heat required for the intermediate superheater the average economy in steam consumption, as before, is about 3.5 per cent. less. In the case of the self-contained type of engine, such as the Wolf "locomobile," the secondary superheating by waste flue gases is of negligible expense.

The curves shown in Fig. 1 are the results of three series of tests notable mainly for the high degrees of primary and secondary superheating. The lower set of curves show the dependence of the indicated load on the terminal pressure. The load curve lies higher as the superheat is greater, and the resulting difference, due to the amount of superheat, on the indicated load with a given terminal pressure is considerable.

The middle set of curves show the steam consumption for the indicated and effective horsepowers, the latter by the shaded lines. The curves are flat throughout. The higher the superheat the lower in the curve will be the point of most favorable steam consumption, and from this and from the steeper path of the expansion line at the higher temperature, it undoubtedly follows that high superheating yields a fuller expansion value.

Fig. 2 shows the subordination of steam consumption, heat consumption and thermodynamic efficiency to steam tem-

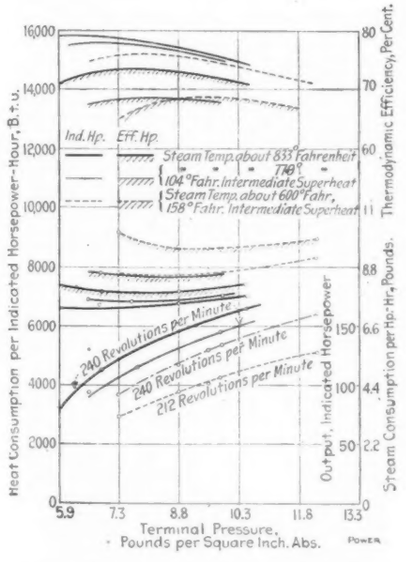

Heat Consumption per Indicated Horsepower-Hour, B.t.u.
Thermodynamic Efficiency, Per Cent.
Steam Consumption per Hp.-Hr., Pounds.
Output, Indicated Horsepower
Ind. Hp. Eff. Hp.
Steam Temp. about 833° Fahrenheit
" " " 770° "
104° Fahr. Intermediate Superheat
Steam Temp. about 600° Fahr.,
158° Fahr. Intermediate Superheat
240 Revolutions per Minute
240 Revolutions per Minute
212 Revolutions per Minute
Terminal Pressure, Pounds per Square Inch. Abs.
POWER

FIG. 1. RESULTS OF TESTS WITH HIGH DEGREES OF PRIMARY AND SECONDARY SUPERHEATING

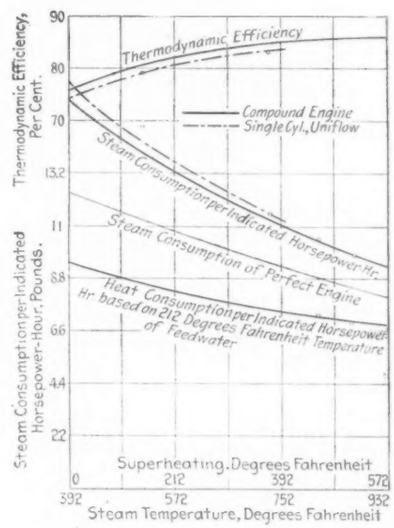

Thermodynamic Efficiency, Per Cent.
Thermodynamic Efficiency
Compound Engine
Single Cyl., Uniflow
Steam Consumption per Indicated Horsepower-Hr.
Steam Consumption of Perfect Engine
Heat Consumption per Indicated Horsepower-Hr. based on 212 Degrees Fahrenheit Temperature of Feedwater
Steam Consumption per Indicated Horsepower-Hour, Pounds.
Superheating, Degrees Fahrenheit
Steam Temperature, Degrees Fahrenheit

FIG. 2. STEAM CONSUMPTION AND THERMODYNAMIC EFFICIENCY WITH DIFFERENT STEAM TEMPERATURES

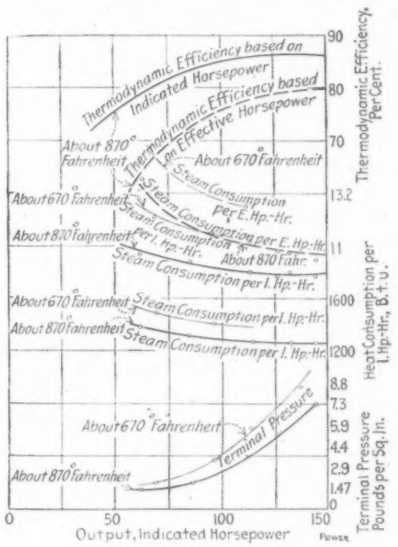


FIG. 3. RESULTS OF TESTS WITH STEAM AT 670 AND 870 DEGREES

*The term "cylinder efficiency" is used here as the equivalent of the German *Gütegrad*, which expresses the fractional value:

$$\frac{\textit{Steam consumption in a "no-loss" engine with incomplete expansion}}{\textit{Steam consumption in the actual engine}}$$

perature. With free exhaust, the theoretical influence of superheating is greater than when operating condensing, but, on the other hand, its effect on the losses is less. This is noticeable in the path of the thermodynamic-efficiency curve.

When running condensing the saving with steam at 660 degrees Fahrenheit is 27.5 per cent.; while when running non-condensing the increased consumption is 37.5 per cent.

As regards the lesser steam-temperature drops with free exhaust, particularly in the low-pressure cylinder, intermediate superheating has but little economy significance, and the heat consumption and the thermodynamic efficiency are hardly affected.

Fig. 3 shows the results from two series of tests—one employing steam at 670 degrees and the other at 870 degrees. The influence of the load on the steam consumption is here somewhat greater than when running condensing.

Influence of Vacuum

For vacuums from zero to something less than 25.5 inches the steam-consumption curve follows an almost straight path; with higher vacuums it approaches more closely the horizontal.

The efficiency of the high-pressure cylinder is less than that of the low-pressure cylinder, partly because the temperature drop of the steam in the former is the greater. With increasing vacuum the proportionate load of the low-pressure cylinder becomes greater as does the cylinder efficiency of the complete engine. The latter reaches its highest value with about 80 per cent. vacuum. With higher vacuums the losses increase, due to the throttling effect between the low-pressure cylinder and the condenser, and to the heat interchange resulting from the greater temperature drops, particularly in the low-pressure cylinder.

Heat Distribution

Figs. 4 and 5 show the dependence of the heat distribution on the load and on the temperature of the steam. The effect of throttling action on the work capacity was determined from the Mollier heat-entropy chart. To simplify matters it was assumed that the actual quality of the steam at the terminal pressure represented the theoretical quality at a like terminal pressure, a condition very nearly true for the low-pressure cylinder; also, that the loss through the incomplete expansion of the compressed steam is negligible. The remaining losses, including that due to the heat exchange between the steam and the walls, were taken together as residual losses.

As plotted in Figs. 4 and 5, the cylinders are considered separately and are supposed to have apportioned to them the actual pressure and temperature drops referred to the theoretical work capacity of the cylinders with complete adiabatic expansion (Clausius-Rankine cycle). For better comparison all values are expressed in hundredths of the theoretical load. Finally, the losses in both cylinders due to throttling action and to incomplete expansion are taken together and referred to the theoretical work capacity represented by the total pressure and temperature drops.

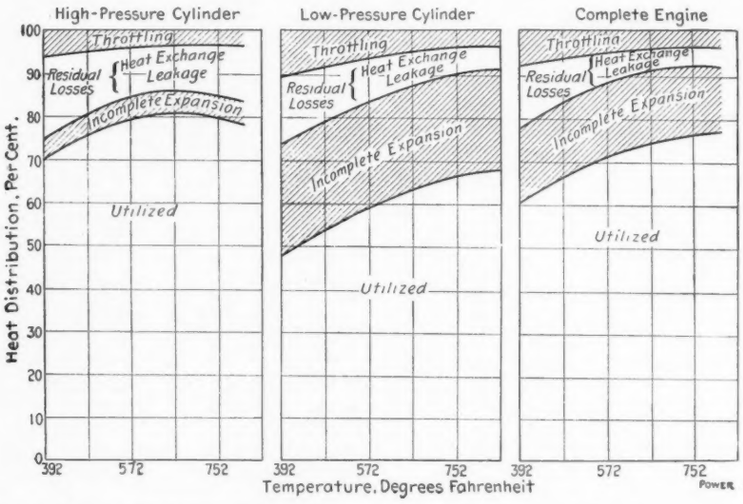


FIG. 5. HEAT DISTRIBUTION IN HIGH- AND LOW-PRESSURE CYLINDERS AND IN THE COMPLETE ENGINE

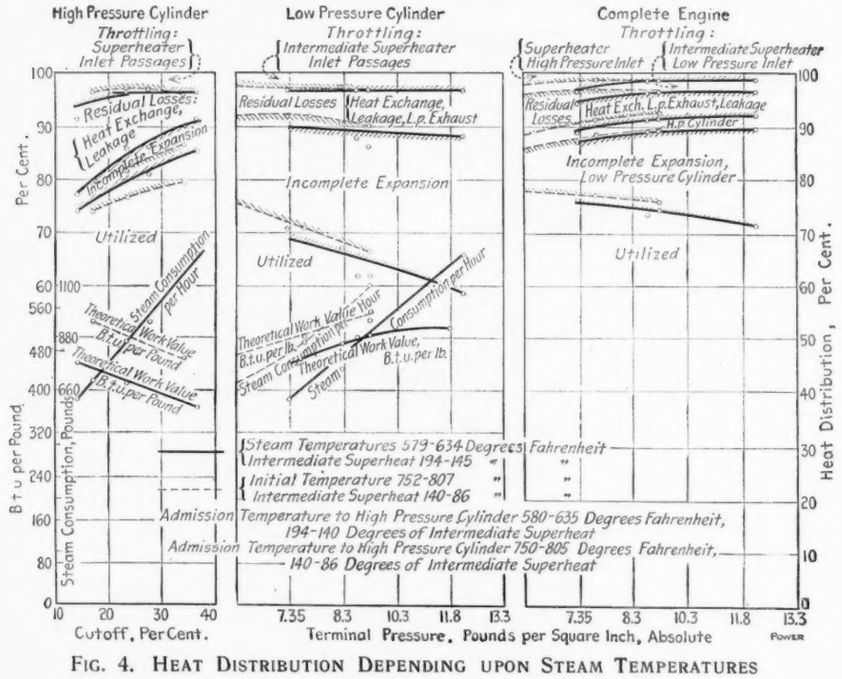

High Pressure Cylinder
Low Pressure Cylinder
Complete Engine
Throttling:
Superheater Inlet Passages
Intermediate Superheater Inlet Passages
Residual Losses
Heat Exchange, Leakage, L.p. Exhaust
Incomplete Expansion
Utilized
Steam Consumption per Hour
Theoretical Work Value B.t.u. per Pound
Steam Consumption, Pounds
B.t.u. per Pound
Per Cent.
Heat Distribution, Per Cent.
Steam Temperatures 579-634 Degrees Fahrenheit
Intermediate Superheat 194-145 "
Initial Temperature 752-807 "
Intermediate Superheat 140-86 "
Admission Temperature to High Pressure Cylinder 580-635 Degrees Fahrenheit, 194-140 Degrees of Intermediate Superheat
Admission Temperature to High Pressure Cylinder 750-805 Degrees Fahrenheit, 140-86 Degrees of Intermediate Superheat
Cutoff, Per Cent.
Terminal Pressure, Pounds per Square Inch, Absolute
POWER

FIG. 4. HEAT DISTRIBUTION DEPENDING UPON STEAM TEMPERATURES

The curve of utilized heat rises rapidly and is in accord with the increase of the working steam volume and with the decrease in pressure and temperature drops in the cylinder; these reduce the residual losses resulting from heat interchange from about 13 per cent. with 20 per cent. cutoff to about 5 per cent. with 36 per cent. cutoff. It is noteworthy that the solid-line curve of thermodynamic efficiency lies higher than the dotted line which refers to tests with a higher superheat of only about 212 degrees Fahrenheit. In the low-pressure cylinder incomplete expansion is the chief source of loss.

Fig. 5 shows the heat distribution as referred to a steam temperature corresponding to a boiler pressure of 220 pounds and a terminal-expansion pressure of 9.2 pounds. In the high-pressure cylinder the chief losses are through heat interchange through the cylinder walls, and with saturated steam they amount to about 19 per cent.; with increasing superheat they fall to about 10 per cent.

The loss through throttling effect decreases with increasing temperature on account of the decreasing friction of flow. The loss through incomplete ex-

pansion is but slightly influenced by the temperature. The thermodynamic efficiency reaches its highest value with a temperature of about 660 degrees.

Among the losses in the low-pressure

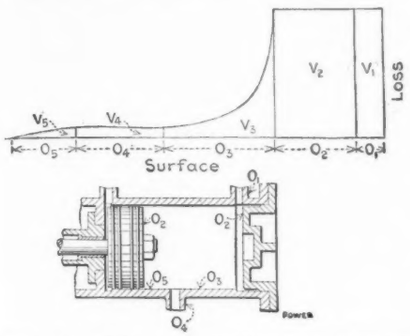


FIG. 6. SHOWING DETRIMENTAL EFFECT OF UNIT SURFACES FOR THE UNIFLOW CYLINDER

cylinder the greatest is that due to incomplete expansion.

NATURE OF THE SO CALLED UNIFLOW SYSTEM

The heat exchange between the steam and the cylinder walls, the chief source of loss in reciprocating engines, grows per unit of area with the greater time of contact, with the greater temperature differences between the steam and the walls, and with the force of flow and the whirl of the steam. The injurious effect is greatest for those surface areas which are in live-steam contact throughout a revolution and which, moreover, are exposed to the greatest temperature differences of entering and outgoing steam. Such are those of the ports and steam passages and of the heads and piston. Of the greatest effect on heat loss is the condition whether the steam retains its superheat or becomes saturated even during expansion. With this in view cylinders operating under similar conditions can be compared with reference to the loss effect of the surfaces, though a

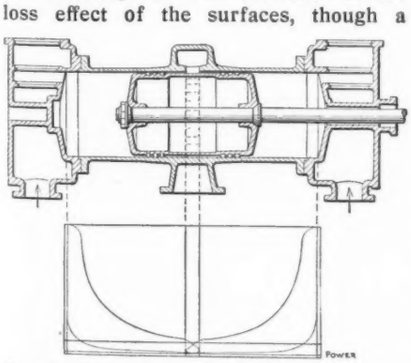


FIG. 7. UNIFLOW CYLINDER WITH DEEP PISTON

comparison between a single cylinder and a compound engine is not possible on account of the other differences of steam density, etc. The economy value of the so called uniflow design is based mainly on the fact that the injurious surfaces of the exhaust passages in the end of the cylinder disappear.

In Fig. 6 is shown the detrimental effect of unit surfaces for the uniflow cylinder. The losses apportioned to the cylinder walls through the unit surfaces V_3 — V_5 are very small. If account is taken of the important influence of the steam flow on the heat loss through the walls, especially in the passages, the advantage of separating the exhaust channels from the live-steam space becomes more apparent.

HEATING THE CYLINDER HEADS

The extent of the clearance is in no way important as to results. This is proved by the favorable results in atmospheric-exhaust operation with from 10 to 12 per cent. clearance. The detriment of surfaces depends, apart from their own extent, on that of the temperature differences, and particularly on the continuance and force of the steam flow. Consideration of the latter leads to the demand for the highest possible temperature for the steam-space walls

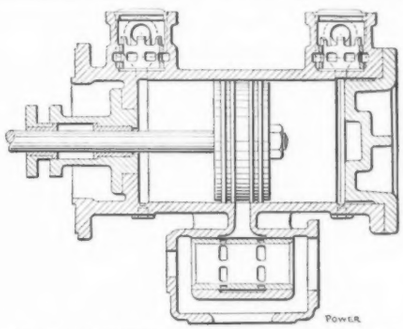


FIG. 8. UNIFLOW CYLINDER WITH EXHAUST PORTS OUTSIDE OF STEAM SPACE

nearest the incoming steam and the lowest possible for the walls of the outlet passages; a demand which, in part, is met by heating the cylinder head with live steam. From the heated cylinder heads to the exhaust-cooled mid-cylinder point a diminution of wall temperature takes place in uniform direction with the steam flow. The uniformity of direction is of secondary import. A recognized disadvantage of the uniflow cylinder, Fig. 7, is the low-temperature piston, because of the excessive cooling of its surfaces by the escaping exhaust, especially at the moment of release, and because the piston surfaces are open to condenser pressure through 90 per cent. of the stroke. This effect, though, in view of the advantages offered by the location of the exhaust ports outside of the steam space, must not be overestimated. With a short piston, such as is shown in Fig. 8, this is largely avoided, although a valve is needed to govern the steam release. Such a design has the further advantage that the compression can be lessened some 60 per cent.

The uniflow cylinder shown in Fig. 7, with main piston release, is tied to a high compression of about 90 per cent. of the stroke. This high compression is a necessary evil of this design.

The disadvantages of high compression are materially lessened through the high

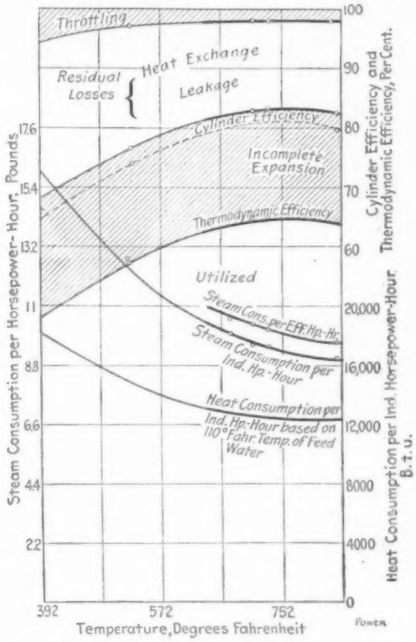


FIG. 9. STEAM CONSUMPTION AND HEAT DISTRIBUTION OF UNIFLOW ENGINE AT INITIAL PRESSURE OF 220 POUNDS AND TERMINAL PRESSURE OF 13 POUNDS

temperature of the surfaces of the heads and inlet passages. The means toward increasing the cylinder-wall temperature is the heating and not the high compression. It seems useless, by means of high compression, to produce temperatures which lie far above that of the incoming steam and through such temperatures to obtain surface heating because the heat transfer from the steam to the cylinder walls during compression contradicts the efforts toward an adiabatic curve.

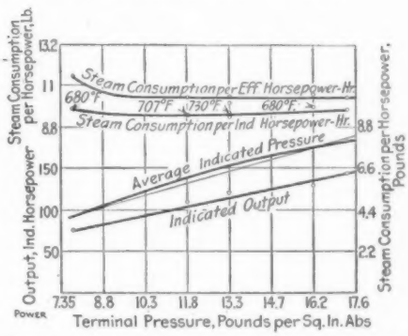


FIG. 10. SHOWING STEAM CONSUMPTION DEPENDENT UPON TERMINAL PRESSURE

The cylinder shown in Fig. 8 was constructed for high superheat and for that reason was wholly unprovided with any jacket heating. The tests with saturated steam and moderate superheating are of scientific value because by comparison

with the results from such engines as are provided with jacketing and head heating the influence of superheating is shown.

Fig. 9 shows the steam consumption and heat distribution of a uniflow engine as dependent upon the temperature at an initial pressure of 220 pounds and a terminal pressure of about 13 pounds absolute.

Fig. 10 shows the steam consumption as dependent on the terminal pressure with a boiler pressure of 220 pounds and a vacuum of about 27 inches. The most favorable steam consumption per indicated horsepower-hour is reached with a terminal pressure between 10 and 12 pounds.

From the flat path of the curve of steam consumption per indicated horsepower-hour with a terminal pressure between 8 and 17 pounds, and by comparison with Fig. 1 it follows that the uniflow engine utilizes expansion less favorably than does the compound engine. This is particularly so in the absence of head heating. There exists a balance between the losses due to heat interchange and to incomplete expansion which is to be considered as a thermal deficiency of the uniflow engine.

The behavior with free exhaust is the same as when condensing. The most favorable steam consumption per indicated horsepower-hour is reached with a terminal pressure of about 24 pounds absolute. With a terminal pressure of 34 pounds per square inch the consumption is about the same.

A set of comparative tests showed a saving in steam consumption of about 27 per cent. through running condensing with a regular compound engine, whereas with the uniflow engine, utilizing about 60 per cent. compression, the saving due to condensing amounted to only 18 per cent.

There is not much difference between the steam consumption of the uniflow engine and the ordinary single-cylinder engine with jacketed heads and head-contained distribution valves.

Referred to the effective horsepower, the consumption figures are a measure of comparative economy as between the compound and uniflow engines, wherefore the mechanical efficiency must not remain unconsidered. With free exhaust this is of still higher importance.

Conclusion

With compound working, the highest steam temperatures are proved to be advantageous. Through superheating, expansion is used to better advantage in that the terminal pressure is advantageously smaller as the superheat is greater. The losses occurring in the high-pressure cylinder increase the theoretical work capacity and the low-pressure cylinder efficiency; hence the loss through heat interchange, referred to the combined cylinders, is very small and becomes even smaller as the arithmetical mean of the respective losses in the individual cylinders becomes less.

The economically favorable load for the compound engine corresponds with a terminal pressure of about 9.5 pounds absolute, as against one of about 14.7 pounds for the uniflow engine.

In connection with the lesser expansion in the uniflow cylinder is the result that high superheating is of much less value. The object of superheating is accomplished when the steam leaves the cylinder in a dry, saturated condition; therefore, with a lesser expansion, less superheating suffices.

The greatest thermal advantage reached in the uniflow engine is that the exhaust passages are remote from the heads, but the flow direction is of little significance.

Notwithstanding its thermal advantage, the uniflow engine does not equal the compound engine in heat utilization. With the uniflow cylinder, superheating is indispensable, but high superheat seems useless; the thermal and mechanical disadvantages of the uniflow engine based on high compression become more evident the higher the back pressure, and in free-exhaust operation, especially under back pressure, the uniflow engine could be improved.

The appearance of the uniflow engine has affected steam-engine building in an active and fruitful manner and has happily encouraged efforts toward a further development of steam power.

A Practical Power Plant Oiling System

By Frank S. Bunker

Both gravity and pressure oiling systems are in general use and differ only in that in the one the pressure is furnished by gravity and in the other by pumps. By proper pipe arrangement the two systems may be so combined as to secure the best features of each. Both systems should have primary filters, washing filters, settling and storage tanks. Boiling tanks are not a necessity, though very useful for a thorough cleansing of the oil.

Nearly all power plants have basement space which can be converted into the necessary oil department. Fig. 1 shows a typical arrangement. At some place high enough to cause the desired gravity pressure, and preferably under the roof truss near the side wall of the building, the main storage tank should be placed. This should be large enough to hold sufficient oil for 24 hours' run. To allow

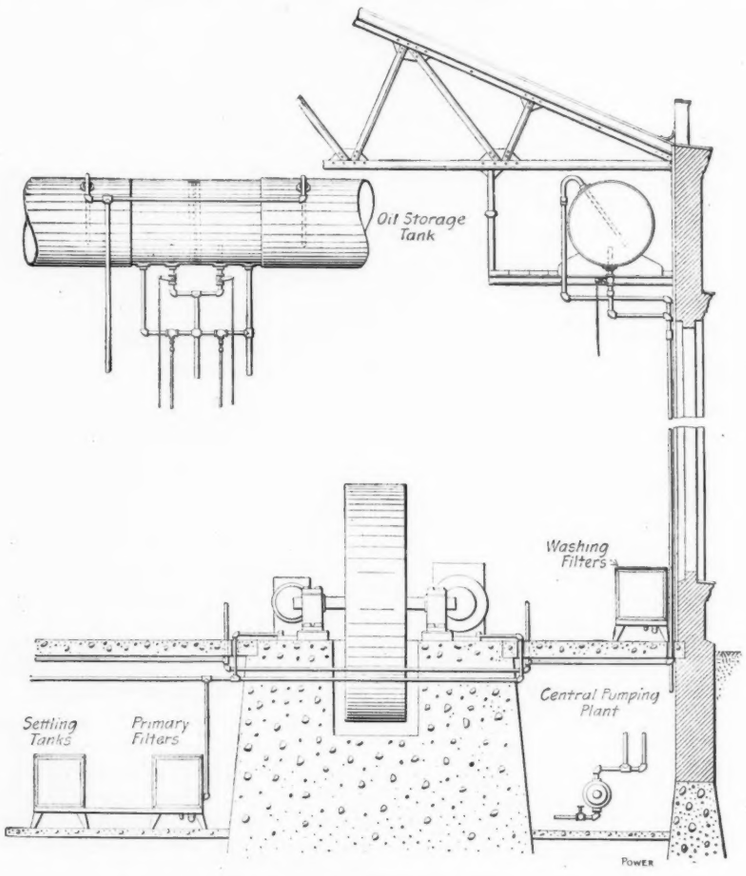


Fig. 1. Elevation of Typical Oiling System

for cleaning and repairs it should be divided into two or more compartments, as shown at the upper left of Fig. 1. The inlet pipes should go over the top of the tank at the end, turn down and extend to within a few inches of the bottom. Owing to the large amount of oil in the tank the circulation is slow and allows foreign matter which may be present to settle to the bottom. The pipe arrangement shown allows either end of the tank to be used alone or the two used together, and if for any reason one compartment is to be emptied it may be accomplished either to the engines or through a separate pipe.

Telltale

It is always advisable that the man in charge of the plant or watch may know at a glance the amount of oil that is in the tank. The string-and-float method is antiquated and often unreliable and dangerous. Fig. 2 illustrates an arrangement which not only shows the amount but commands attention with its alarms and danger signals. As the oil lowers in the tank the electric brush shifts from one of the contact plates to another on the vertical wooden rod and lights a series of lamps on a board correspondingly arranged. Where the oil reaches a level indicating one-third of a tank left, an 8-candlepower green lamp lights as a warning signal. A further lowering of the oil lights a 32-candlepower red lamp, and at a still lower level, say, 2 inches above the top of the sediment pipe, a 16-inch gong rings.

Filters

The oil as it leaves the engines is more or less heated by contact with the frictional surfaces as it carries in suspension some grit and foreign matter. The most of this foreign matter is dust and grit which has settled from the air. This must be removed by filtration.

The first or primary filter, Fig. 3, consists of a steel tank divided into four or more compartments. The division plates reach about three-quarters of the way to the top and are surmounted with sheet-steel pans or boxes. These pans rest on felt gaskets to make them nearly oil tight and that half of the bottom of the pan which is away from the inflowing oil is perforated. Baskets made of fine wire mesh are placed in these boxes and are filled with curled hair through which the oil is strained. Leading away from the tops of the division plates are curved baffle plates which extend entirely across the filter and which allow the oil to sink easily into the main body without creating eddies, whirlpools and other disturbances.

There should be two of these filters, which may be used singly or in series.

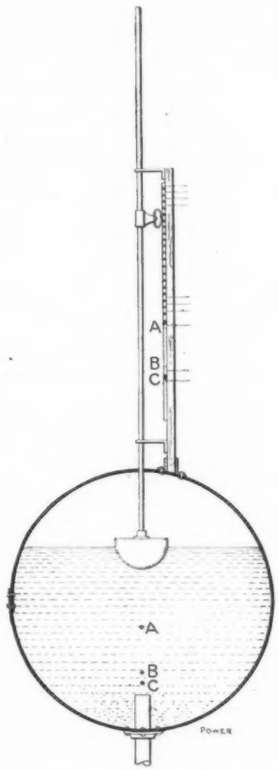


Fig. 3. Cross-section of Storage Tank

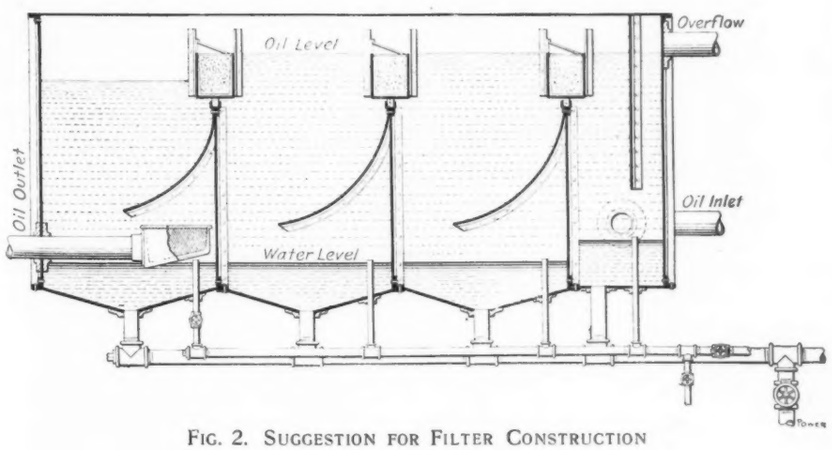


Fig. 2. Suggestion for Filter Construction

An Air Receiver Explosion

By Robert E. Newcomb

The writer is familiar with a power plant consisting, in part, of an old two-stage duplex belt-driven air compressor and an air receiver; the air is compressed to 80 pounds.

One afternoon the engineer was startled by a terrific report followed by a long and loud screech. The engineer examined the air receiver, where the disturbance seemed to be, and found that the spring pop-safety valve had burst. The compressor was stopped and a further investigation was made, when it was then noted that the lower section of the receiver was a dull red and that the bottom head had been distorted so that the receiver stood some 2 inches off from its foundation, excepting at the center portion of the lower head.

A hurried investigation showed no rupture in the air piping or the receiver. The relief valve was then replaced and the compressor started. Everything was then apparently in good order, except the receiver, which showed a few small leaks at the joints of the bottom head and shell. These joints were soon corked, and, up to the present, no further evidence of injury has appeared.

A mineral lard oil diluted with a large percentage of kerosene had been used during the previous winter with remarkably good results, and as its use was continued into the warm weather, the mixture undoubtedly caused the explosion.

In this case it is fortunate that the relief valve was weak and burst, as otherwise much greater damage would probably have resulted as the pressure must have risen almost instantly.

Without doubt, compressed air is the safest kind of power and there is little or no danger in storing it, but the introduction of kerosene or gasolene into the oil to clean the cylinder and valves generally results disastrously. A solution of soft-soap and water is an excellent cleanser for an air cylinder and may be used without danger; it is even recommended where high-grade oils are used.

As the washing effect possessed by steam is lacking in air, it will be found that oil remains much longer in an air cylinder than in a steam cylinder; hence, a surprisingly small quantity of good oil will lubricate an air cylinder without difficulty. Only the best oils of high flash and fine test should be used and they are the safest and most economical in the long run.

A frequent cause of explosion in compressed-air discharge pipes and receivers is an accumulation of carbon in the pipes or of oil in the receiver. Oil should be drawn off from all air receivers at frequent intervals.

Another cause of air-compressor explosions is the high temperature caused by the churning or continued recompressing of the air when the discharge valves leak.

Electrical Department

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Induction Motor Repairs

By R. H. Fenkhausen

Removing Coils

There are two methods of holding stator coils in place in use by the different makers. The best method and the

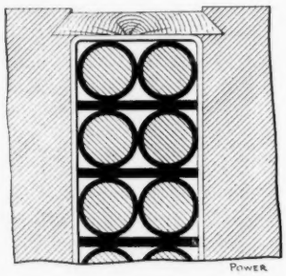


Fig. 12. Wedge Fastening

one almost universally used on modern motors is shown in Fig. 12. Hard-fiber wedges are driven into dovetailed grooves in the teeth and not only hold the coil firmly, but protect it from oil and chips which may be drawn into the airgap by the ventilating fans on the rotors. With the other method, shown in Fig. 13, there is no protection over the coil, which is held in place by lashings of twine looped around an insulated iron ring and each coil in turn. This method is no longer used except as an anchor to prevent movement of the overhanging portions of the coils in motors designed for very severe service; in such cases it is used in addition to the wedges, and the loops are at the extreme ends of the coils. See Fig. 3, October 24 issue.

When a coil is to be removed, enough wedges must be driven out to allow the

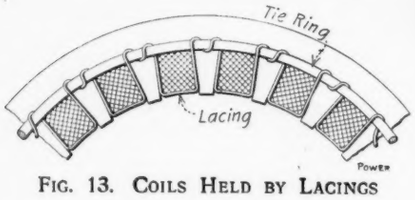


Fig. 13. Coils Held by Lacings

coils under which it lies to be raised clear of the core. The lacings, if any, must also be cut for a corresponding distance. The number of coils which must be raised to allow the removal of a damaged one, varies with the type of winding from the extreme shown in Fig. 4, which allows removal of any coil without disturbing the adjacent ones, to the other extreme represented by a bipolar diamond winding which necessitates raising half the entire winding.

Practically all windings except the concentric require the removal of all the coils spanned by one pole, but as each winding will be treated in its proper place, no further distinction need be made here.

After the lacings have been cut away for the proper distance the end must

Fig. 14. Starting a Coil

be made fast (otherwise the entire circle of coils will loosen up, as the lacing is in one continuous piece) and all connections between coils carefully unsoldered.

The coils must never be pried out of the slots with a screwdriver or trouble is sure to ensue, especially if the coils are old and brittle. The first coil is the hardest to start, owing to lack of working space, so a little time must be given to its removal. If a strip of ¾-inch linen tape be slipped under the upper half of the coil at each end and tied into a loop, a screwdriver may be inserted in each loop in turn and the coil gradually raised from the slot, using a small block for a fulcrum, as represented in Fig. 14. The tape sling should be as close to the stator core as possible in order that no bending will occur if the coil is tight in the center of the slot.

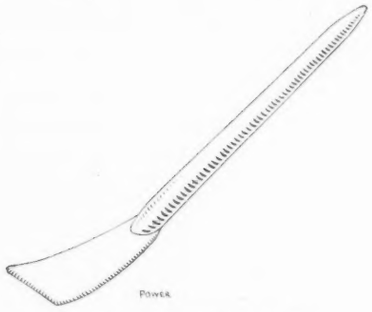


Fig. 15. A Safe Coil Pry

After the first upper coil is dislodged there is room on one side of the next one which may be used for the insertion of a coil iron of the form illustrated in Fig. 15. In making this iron great care must be used to round all corners and edges well in order that no damage will be done to the coils in prying them out of the slots. After the top parts of a number of coils equal to the pitch have been raised, the lower half of coil one is ex-

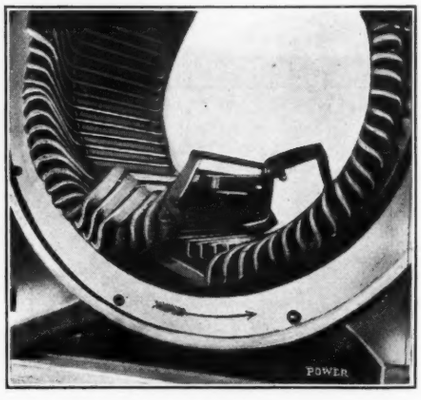


Fig. 16. Order of Removal

posed and may be removed from the slot as shown in Fig. 16 and repaired. If more than one coil must be removed it is, of course, necessary to remove them in a direction corresponding to the arrow in Fig. 16 or else more top coils will have to be raised to gain access to the lower halves. It is therefore necessary to begin the raising of the top coils at the proper place in the winding.

Coil Repairs

After removing the damaged coil or coils they should be carefully washed in gasolene and given a minute inspection to determine whether they can be repaired or not. It will be found as a general rule that only one or two turns of the coil have been damaged and new

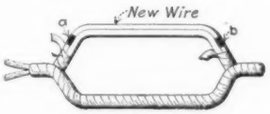


Fig. 17.

Fig. 18.

wire may be spliced in to replace that burned off or pitted.

As the space in the slots is limited, it is not practicable to join the wire in that part of the coil which lies within a slot. The taping must be removed as shown in Fig. 17 from *a* to *b* and a new piece of cotton-covered magnet wire cut to the exact length to fit neatly between the cut ends. A small sleeve connector of thin sheet copper must be made for each joint and rolled up to fit the wire, as illustrated in Fig. 18, the edges being beveled to protect the taping from being cut while driving the coil into place. All of the wire ends and both connectors must next be thoroughly tinned and a piece of cotton sleeving long enough to cover the joint must be slipped on each end of the new wire and pushed back out of the way. The wire must then be bent to conform exactly to the shape of the coil, the copper connectors slipped on, and the joints thoroughly soldered, care being used that no acid is present in the flux used. After the solder has set, the joints must be carefully inspected for sharp projections of solder

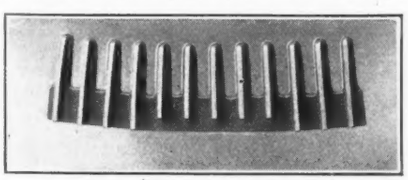


Fig. 19. Finger Plate

which would be liable to puncture the insulation; if none is found, the sleeving may be drawn into place and stretched tightly each way so that it will fit the joint snugly. A coat of orange shellac or insulating varnish should be applied to the repair and when dry, the taping replaced in the original condition. A coat of varnish should then be applied to the entire coil, after which it may be replaced in the stator.

Before the coil is replaced, however, the slot must be carefully inspected for high laminations or lumps of copper burned into the iron by the ground. If this precaution is neglected, the coil will be almost certain to be grounded as soon as it is driven into the slot, as the insulation will be cut open by the rough places should any exist.

If the entire stator winding appears to be in bad shape and the coils are brittle and bear evidence of having been overheated at some time, the only safe procedure is to remove the entire set of coils from the slots for inspection, because the operation of raising the "throw" coils to enable the faulty coil to be removed is sure to crack the brittle taping on the end connections. These cracks will leave openings for the entrance of oil and moisture which will cause the destruction of the winding after a while.

After the coils have been washed in gasolene, a dozen should be selected at random from the lot and bent slightly to test the insulation. If it appears brittle, slit the taping off the coils with a sharp knife, taking care to hold the knife at such an angle that the cotton covering on the wire will not be injured. The

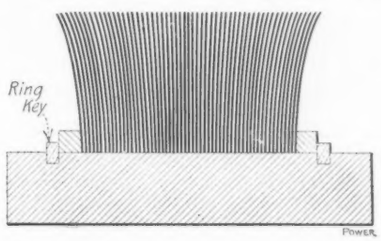


Fig. 20. Unsupported Teeth

cotton should be tested with a knife and if it is not charred and resists an attempt to scrape it off, the coils are worth retaping and the balance of the lot may be untaped.

If, however, the cotton covering appears to be charred or if the copper wire is brittle owing to crystallization, it will pay to scrap the whole winding, because the labor of winding the new coils is only about 25 per cent. of the total labor required for the repair and as the other 75 per cent. is consumed in removing taping, insulating, replacing and reconnecting the coils, it is poor policy to risk a failure for the sake of saving the extra labor involved in rewinding.

If the old coils seem to be in good condition they should be dipped in insulating varnish and thoroughly dried before retaping.

Slot Insulation and Coil Insulation

There appears to be an irreconcilable difference of opinion as to the relative values of slot and coil insulation, and before retaping the coils, the various claims made by the advocates of both methods should be considered. When slot insulation alone is used, the coils are wound on forms and dipped in an insulating compound which holds them in shape. All of the insulation is placed in the slots in the form of treated linen cells reinforced by thin fiber cells for mechanical strength.

That part of the coil lying within slots is, of course, amply protected, both by the cells and the wedges which hold the coils in place, but the end connections and other parts of the coil lying outside the slots are unprotected, and are liable to damage both by careless oiling, and from accidental blows. The only advantages of this method are its cheapness

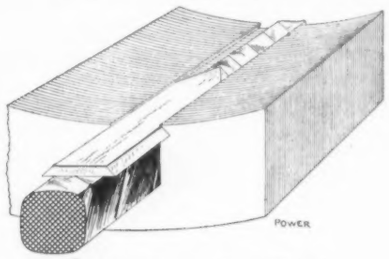


Fig. 21. Short Coil Wedge

and its adaptability to partially closed slots in which coils can be inserted one layer at a time if untaped.

When coil insulation alone is used, all of the insulation is placed on the coil itself in the shape of several layers of insulated paper under the external taping, and the coil may be placed in the slot without any delay due to preparing cells, etc. The disadvantages inherent in this method are that the coil is very stiff and hard to insert in the slots and it is liable to damage by the sharp edges of the core laminations while it is being put into the slots.

By far the best method, in the opinion of the writer, is a combination of the two; one or two layers of taping are wound on the coil and the balance of the total required insulation is put in the

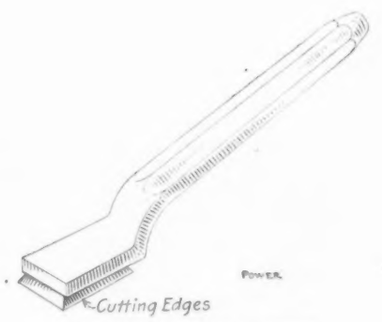


Fig. 22. Groove Cutter

slot. The taping on the coil enables it to hold its shape during the operation of inserting it in the slot and protects the end connections from oil and mechanical injury, at the same time leaving the coil sufficiently flexible to enter the slots readily.

The actual insulation of the coil is mostly furnished by a treated cloth cell which may be left long to facilitate entrance of the coil, and cut off and lapped over under the slot wedge afterward. The treated cloth is protected from sharp corners and high laminations by a cell of extremely tough and thin paper known as "leatheroid" or "fishpaper."

If the combination method is adopted, a sample pair of cells should be made up and a coil taped and pressed between

a pair of fiber jaws in a vise. If the taped coil fits snugly in the cells, the entire winding may be retaped and a full set of cells made. If the coil is too tight, the thickness of the leatheroid cell must be reduced; if it is too loose, more taping must be used on the coil.

After the coils are taped they must be dipped in varnish and after the varnish has set they should be either dipped in melted paraffin or thoroughly "dusted" with talcum powder, in order to facilitate the work of inserting them in the slots.

PREPARING THE STATOR FRAME

On stator frames not provided with "finger plates" (see Fig. 19), the toothed portions of the laminations are not under compression and the teeth spread out at the top, as shown in Fig. 20, leaving spaces between the laminations which take up oil. If the coils are not in good condition they will absorb this oil by capillary attraction, just as a lamp wick absorbs illuminating oil. Therefore, before inserting the insulating cells and coils in the slots of the stator core, it is a good plan to compress the laminated teeth between clamps in order to expel any excess oil. When the teeth are compressed, the oil will be driven out and it must be washed off with gasolene while the teeth are under compression; otherwise, some of it will be drawn back between the teeth as soon as they are released.

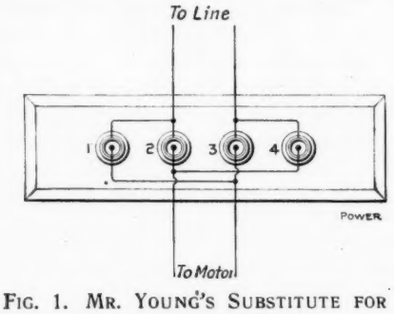


FIG. 1. MR. YOUNG'S SUBSTITUTE FOR A DOUBLE-THROW SWITCH

After the pressure is removed, the laminations should be given a coat of orange shellac mixed very thin so that it will fill up the minute gaps between the teeth and prevent the subsequent entrance of oil. When the shellac has dried, the surplus must be scraped out of the slots and a careful examination made for rough places and high laminations, which must be smoothed off with a fine file if found.

The coils in some types of stator do not fill up the entire depth of the slots, and in such cases it is possible to substitute wedges for the rings and lacings which hold the coils in place. It is not practicable to use full-length wedges in stators of this type, owing to the difficulty of chipping the long grooves required; but a short wedge about one inch long may easily be driven into short grooves chipped into each end of the slot (Fig. 21) by means of the special grooving chisel shown in Fig. 22.

LETTERS

Substitutes for Double Pole Double Throw Switch

A few months ago W. S. Young described the use of plugs and receptacles as a substitute switch, arranged as in Fig. 1. This does not appeal to me as being very "fool proof." If the plugs were in sockets 2 and 3, which would cause the motor to run in one direction, and I were called upon to run it in the opposite direction, it would be just like me to remove the plug in No. 2 and insert it in No. 1 receptacle before removing the plug from No. 3 receptacle, and then my hair would be upended while the resulting short-circuits blew the fuses.

The arrangement indicated by Fig. 2 appeals to me more strongly. Two receptacles stuck up in any old place are connected to the power leads and two plugs connected to the armature leads. By simply removing the plugs and changing them, each to the other receptacle, the direction of current will be changed and there will be no chance of a short-circuit.

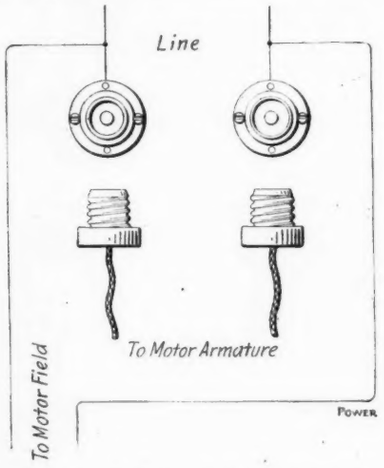


FIG. 2. A BETTER ARRANGEMENT

W. FARBING.

Fort Ward, Wash.

Trouble with Alternators

I have two cross-compound Corliss engines direct-connected to alternators running in parallel. The load is equally divided between the engines and they both run at the same speed. The indicator diagrams are very satisfactory, showing that each cylinder develops the same power.

Nevertheless, there is an uneven humming sound produced by the alternators and the ammeter of one unit is very unsteady, swinging through 50 to 100 amperes. Recently I replaced one set of badly worn collector rings and put the carbons in first-class shape, but there was only a slight change. There is no hunting of either of the engines as I tried every eighth of an inch, setting the counterweight of the governor for increase or decrease of speed.

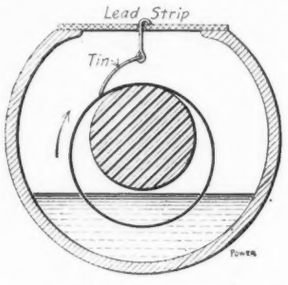
Can anybody tell the cause of the trouble and suggest a remedy?

CHARLES FOX.

Bay Ridge, O.

Curing Oil Throwing

The journal oil rings on a 5-kilowatt exciter dynamo under my charge gave considerable trouble by throwing the oil out on the floor. Thinking that the oil was too heavy I tried lighter oil, with the same result. Then I cut a piece of sheet lead the width of the oil-well opening and a little longer and fastened a strip of tin to it by a piece of copper wire so that the free end of the tin strip would just touch the oil ring, as shown in the sketch. The tin gathered the oil off the outside of the ring and dropped it on the shaft; it also retarded the motion of the ring. Since then I have not been troubled with hot boxes or oil on the floor.



STRIP OF TIN TOUCHING OIL RING

C. C. LONG.

Leesburg, Fla.

Sparking Commutator

Our 6x6½-inch single-acting ammonia compressor is driven through a Morse chain by a 7½-horsepower shunt-wound motor running at 155 revolutions per minute. The head pressure on the compressor is 160 pounds and the back pressure 25 pounds. The motor takes from 26 to 29 amperes and 220 volts and is rated at 30 amperes.

The commutator sparks very badly and the whole motor runs very warm. The brushes have been shifted, the commutator sandpapered and turned down and the brush tension adjusted. In two hours after starting, the commutator sparks as badly as before. I should like to know the cause of the sparking. Does the action of the single-acting compressor have anything to do with it? The machine runs 15 hours a day and is located in a damp place close to the brine pump and suction line. Would a compound-wound motor give better service in this case than a shunt-wound motor?

J. C. HAWKINS.

Hyattsville, Md.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Heating a Shop with Engine Jacket Water

By F. B. Hays

In a small shop operated by a gas or gasolene engine considerable expense can be saved in winter by utilizing the cooling water from the engine for heating purposes. The method employed is shown in Fig. 1, where *A* is the jacket-water outlet pipe, *B* and *C* the heating coils, and *D* the cooling-water return pipe. The pipes *E* and *F* are the circulating pipes connecting the engine with the regular cooling tank. Valves are provided to control all of the pipes.

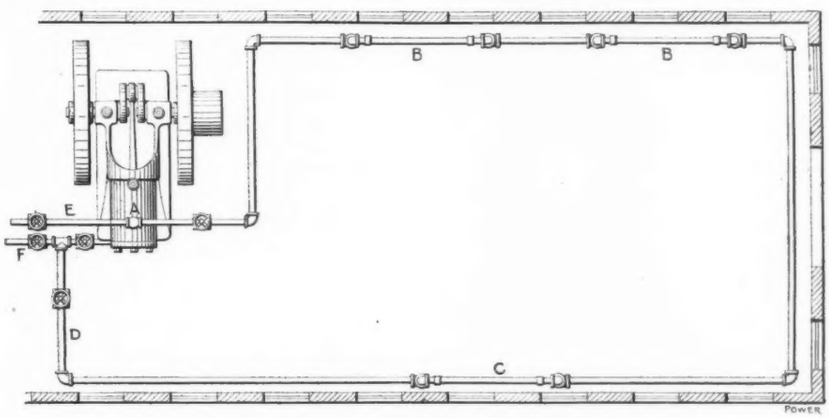


Fig. 1. Plan of Engine Room, Showing Piping

To secure the most efficient operation of the system, the coils and piping should be arranged as shown in Fig. 2, as this arrangement gives better circulation than when the coils are placed on the same level.

If the volume of water passing through the heating coils be regulated by the valves in the supply and return pipes the temperature of the room being heated may be varied to suit the weather conditions. It must be remembered, however, that when these valves are partially closed, the valves in the pipes *E* and *F* must be opened an equal amount to allow the engine to receive the required volume of cooling water.

The amount of space that the system will heat depends, of course, upon the amount of cooling water passed through the engine jacket, and the power and efficiency of the engine. Under ordinary conditions the quantity of heat carried away per hour by the cooling water is from 2000 to 4000 B.t.u. per brake horsepower. A fair average is 3000 B.t.u. per brake horsepower-hour and about one-half of this is available for heating. Multiplying this quantity (1500) by the brake horsepower and dividing by the number of B.t.u. required per hour to heat 1 cubic foot of free air from 20 to 75 degrees Fahrenheit for ordinary climates (or from —25 to 75 degrees for cold climates) gives the number of cubic feet which the system will heat.

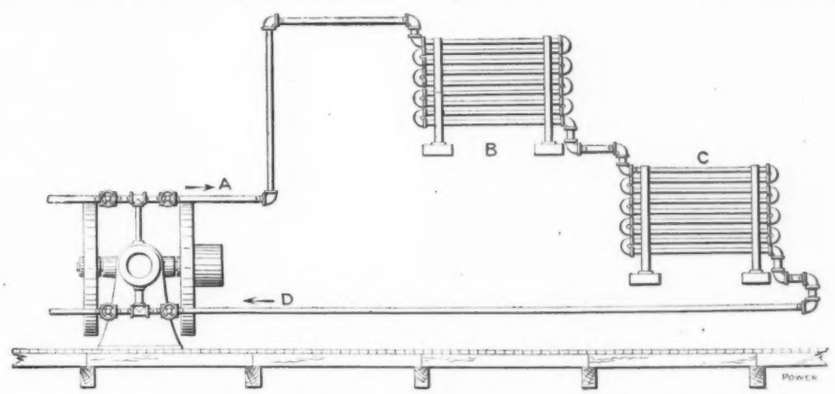


Fig. 2. Arrangement of Coils and Piping to Secure Good Circulation of Water

The number of B.t.u. required to heat 1 cubic foot of air through the required number of degrees of temperature can be obtained from any standard book on heating and ventilating, and will vary somewhat with the construction and exposure of the building.

The heating coils should not be built haphazardly, but should be figured out beforehand by the use of some of the simple formulas found in books and catalogs on heating and ventilation.

Practical Points in the Operation of Diesel Engines

By Hiram R. Low

For some time articles have appeared in the columns of Power, relating to the Diesel engine, its good and bad points, its operation under various conditions, etc. The writer, having had considerable experience with this type of engine, is led to believe that a few points picked up in his experience might be of considerable benefit to some other readers who may be called upon to run a Diesel outfit. First of all, let me say that I can heartily agree with W. F. Caton, who says that the makers of this engine make a grave mistake in claiming that the operation of their engine requires only cheap help; if there is any engine that calls for close and intelligent attention, it is this same Diesel engine, if good results are to be obtained. With a Diesel installation properly looked after, good results are readily obtained.

In some respects this engine is a wonder; one of the astonishing things about it (to anyone accustomed only to other engines) is that it can be started and brought immediately into commission without any previous warming up or other preparatory work, and without any apparent harmful effects, even when the

thermometer stands below zero and everything about the machine is dead cold. Neither does it seem to make any difference in the operation of the engine whether it is a cold day in winter or an extremely hot one in summer, notwithstanding that it is only pure air heated by compression that is depended upon for the combustion of the fuel oil.

Many of the writers who have had something to say regarding the Diesel engine agree that it will run well if the valves are tight and kept free from carbon. There is almost always an "if" about engineering, and right here is where cheap help doesn't fit the Diesel engine. If the carbon is kept from forming, the battle is more than half won.

It is well known that an overload will cause a smoky exhaust, accompanied by deposits on the piston, piston rings and both admission and exhaust valves, but not all operators understand why it does so. The reason is that the cylinderful of air contains just so much oxygen and this amount of oxygen is sufficient for the complete combustion of just so much oil *and no more*. When the engine is running at its rated load, this quantity of oil is being fed and the exhaust should be clear. If an overload is put on the engine, the governor causes the pump to increase its delivery of fuel and the result is that more oil is pumped in than the oxygen in the cylinder can burn completely; consequently some of the carbon in the oil is partly burned, thereby producing smoke. There is no clearer illustration of this than a common kerosene lamp. The wick is the oil pump and when it is turned up to the proper hight there is a clear light (without smoke) for the reason that there is a sufficient quantity of air being admitted through the burner to completely consume the vaporized oil. Now, "overload" the lamp, that is, turn up the wick a little further and thereby increase the supply of oil; there is no more air than before, so that the excess oil cannot be burned. The result is that part of the oil supplied is completely burned and part is partially burned, the latter producing smoke.

An overload can be imposed on one or more Diesel engine cylinders by a clogged atomizer in the fuel-valve bracket of another cylinder. The clogged atomizer admits little or no oil to the corresponding cylinder, which therefore cannot do its share of the work; the work of the other cylinders may thereby be increased beyond their share of the full load, producing incomplete combustion and its consequent smoke. The only remedy in this case is to take the faulty atomizer apart and either thoroughly wash it out with gasolene or kerosene and run a fine wire through the holes, or put in a new one. Another cause of carbon deposit is a leaky needle valve. This will admit oil to the cylinder constantly, the warmth within the cylinder distils it, and the rising temperature during the compression stroke causes it to become heated enough to smoke. Usually a few minutes spent in grinding in the needle valve will cure it. Sometimes, however, the needle valve will leak from another cause which is due to expansion of the "fuel rod" connected to the bell crank that operates the needle valve. Expansion of this rod will cause the bell-crank end or tappet to press against the fiber on the needle-valve body and hold it off just enough to leak. There is considerable pressure on the injection line under running conditions, and a small leak here shows up amazingly.

Other causes of smoke are leaky piston rings, which of course cut down the pressure and temperature of compression (this can usually be identified by the smoke coming out of the crank-case vent); leaky admission valves, exhaust valves or safety valves, and on the one-cylinder engine, a leaky starting valve.

The starting valve should be well looked after and the stem kept free from carbon with liberal doses of kerosene. The writer knew a case where the whole starting line of piping was ripped off by an explosion backing up through a stuck starting valve. Care should be exercised lest too much oil is fed to the compressor, on this account.

Another prolific cause of smoke, and at the same time a loss of power, is late admission of fuel. A good way to find out at which point in the stroke the fuel valve is opening is to slowly bar the engine around until the crank of the cylinder fed by the suspected pump is within a short distance of the top center. Having previously lifted the admission pipe out of its flange so as to be able to hear the least escape of air, turn on the injection pressure from the bottles and bar around until the valve just "cracks," when the pressure can plainly be heard going into the cylinder. This should occur when the main crank is 1 per cent. ahead of dead center, and the center of the roller that runs on the fuel cam should just be in line with the opening line which is plainly marked on the cam. If it is not in this position it can be put there very readily by shifting the cam nose either ahead or back, as occasion requires. It should be remembered, in this connection, that too early an opening of the fuel valve will cause a very pronounced pound, owing to premature ignition. Late admission will cause smoke and loss of power owing to the fact that the air in the cylinder is becoming rapidly cooled by expansion and, also, the piston is rapidly moving away from the head when ignition occurs, giving somewhat the same effect that late admission would on a steam engine.

Should the injection pressure become too low, that also will cause smoke; if it is too high, a pound will be noticed. There is a happy medium as to the proper injection pressure to carry under different loads and when found it will go a long way toward the smooth running of the engine.

CORRESPONDENCE

A Diesel Engine Diagram for Comment

The accompanying indicator diagram was taken from one cylinder of a Diesel engine driving a 300-kilowatt generator. The load was 275 kilowatts and the speed 164 revolutions per minute at the time the diagram was taken. The engine is a twin unit, each half of which has three

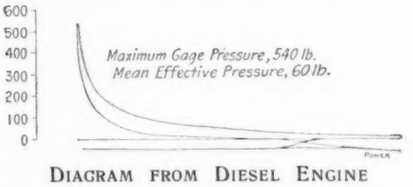


DIAGRAM FROM DIESEL ENGINE

cylinders 16x24 inches. I will appreciate comments on the diagram in POWER by other readers who have had experience with Diesel engines.

WILLIAM R. CATON.

Southbridge, Mass.

Coal Consumption of Producer Plant

The gas engine and producer plant of which I have charge consists of one 100-horsepower engine and producer and one 50-horsepower engine and producer, the engines being direct connected to electric generators. The larger unit is always in service, the other being kept in reserve. The load averages 480 kilowatt-hours for 9½ hours per day, or at about the same rate for 54 hours per week, the engine being shut down the remainder of the time. However, the fire in the producer is never out. Buckwheat coal is used and some of it is of a poor quality.

I would like to hear from some engineers having had practical experience with producer-gas plants as to what the coal bill ought to be for this load and load factor. The engines are in good condition generally, although the pistons leak some. Would it be possible to save coal by speeding the engine above its present speed of 200 revolutions per minute? What temperature should the gas have when it enters the engine, and what should be the temperature of the water from the scrubber where the gas goes direct to the engine, as in suction-producer installations?

A. A. RICE.

Chicago, Ill.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Turbine Foundations

A properly lined and balanced turbine should not require that the base be entirely surrounded by concrete, leaving barely room to get at the step-bearing bolts.

One turbine was installed on the floor, which was supported by I-beams; and as the turbine did not operate satisfactorily, of course the cause was attributed to the foundation. But when the troubles in the turbine were remedied there was no further occasion to blame the foundation.

The foundation was far from ideal, however; the I-beams were tied in the walls and fastened to them were steam pipes running to trip hammers in the blacksmith shop.

With the turbine stopped, the jar from the trip hammer could be felt on top of the shaft and the deflection of the shaft indicator was 0.005 to 0.008 inch when the turbine was stopped.

Notwithstanding all this, after the machine was fixed it ran smoothly.

G. SMITH.

Lynn, Mass.

"Differential" Chain Block

It is probable that all who read this are familiar with the simple "differential" chain block, which consists of two pocketed chain sheaves at the top, a single sheave at the bottom and a continuous chain for operating. The yokes and the hooks must, of course, be included for sustaining the whole and carrying the load.

With the 1-ton block, as ordinarily constructed, the operator must pull 30 feet of chain in order to hoist the load 1 foot; in other words, the block has a velocity ratio of 30 to 1, and were it not for friction—which, in spite of the simplicity of the mechanism, generally amounts to over 60 per cent. of the power applied—the weight lifted would be 30 times the pull exerted by the operator. Having hoisted the load 1 foot, return it to its original position; to do so, but 28 feet of chain will have to be pulled. What has changed the ratio from 30 to 1 to 28 to 1, and what has become of the remaining 2 feet of chain?

As is almost invariably the case with a paradox, the solution of the problem is easy—too easy to be considered a test of the reader's mechanical ability unless the time required to answer the question be considered. Nevertheless, a good many high-class engineers have been puzzled for a time by the above statement.

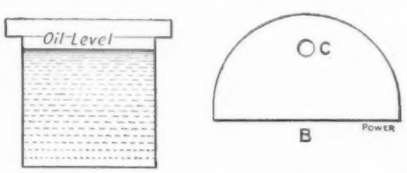
The solution may also lead to a simple rule for determining the velocity ratio of a block of this type without resorting to actual measurements of any kind.

H. M. PHILLIPS.

Pittsburg, Penn.

Finding Flash Point of Oil

Much discussion has arisen as to the proper point to which oil should be heated before being fed to oil burners. The first thing to do is to find the flash point and then heat the oil within 5 or 10 degrees of the flashing point. The oil will flow through the pipes more readily when hot than when cold and will burn better. Heating the oil will also tend to precipitate what moisture it contains to the bottom of the oil tank, from which it may be removed by pumping. A simple method for ascertaining the flash point is given herewith. The apparatus required is a Fahrenheit thermometer reading to 300 degrees, a Bunsen burner tripod, a Bunsen burner, an iron dish (sand bath) about as large as a good-sized saucer and a copper cup as per sketch.



APPARATUS USED IN FINDING FLASH POINT OF OIL

Fill the sand bath two-thirds full of common sand and place it on the tripod. Then cover the sand bath with a piece of sheet asbestos, leaving a hole in the center of the sheet to admit the copper cup, which has been filled with oil to the level shown in the sketch, allowing the bottom of the cup to rest on the sand. Then take a small piece of sheet asbestos *B* which has a small hole *C* cut, through which the thermometer is inserted, and cover the top of the copper cup with it. Insert the thermometer through the hole *C* until the bulb is immersed to one-half the depth of the oil in the cup. This can be done by suspending the thermometer with a piece of string from some convenient nail. Now place a flame under the sand bath and heat it gently.

A Bunsen burner is best for this purpose, but any small flame will answer. The oil should show a rise in temperature of from 5 degrees to 8 degrees a minute. When the oil reaches 100 degrees Fahrenheit, pass a small flame over an opening in the corner above the surface of the oil at every 2 degrees rise in temperature until a small bluish flame appears on the surface of the oil. Note the temperature at which this takes place and call this temperature the flash point of the oil.

If gas is available, a small piece of glass tubing may be heated in the center until soft and then drawn out to make a jet. When inserted in a piece of rubber tubing this makes an excellent way of obtaining a small flame (¼ inch long) to pass over the surface of the oil when testing. The method described will give the flashing point of the oil closely enough to enable one to judge the point at which to heat the oil.

WILLIAM PATTERN.

San Antonio, Texas.

Water Wrecked Low Pressure Cylinder

At three minutes past six o'clock on Wednesday, September 27, the low-pressure side of a cross-compound engine was wrecked by a dose of water. As is customary in some mills, the main engine is kept running some few minutes after the whistle blows to keep the lights on, and enable the operators to get out of the building.

This engine has been running for four years under the same general conditions without a mishap of any kind. The vacuum is maintained on the engine with a jet condenser which will not siphon over, on account of having a lift of about 3 feet; as a matter of fact, there is a pressure of 1.5 pounds shown by a gage attached to the priming pipe. The priming pump is kept running during the time the engine is in service.

The boiler house, containing three upright boilers, is situated across the river from the mill, the main steam line being

approximately 150 feet long. It is provided with an ample separator situated within 10 feet of the high-pressure cylinder. The separator and receiver are both drained of condensation by traps of ample size which have always worked satisfactorily. The water used in the boilers is taken from the river and is quite dirty; at some seasons it contains more or less chemicals from dyeing establishments located further up the river, and the boilers had a tendency to prime.

The load was practically all off the engine at the time of the mishap, the cutoff being so short that the receiver gage showed but 3 pounds pressure.

Here is a case where everything was seemingly the same as usual, and within one minute of the time for shutting down, the engine got a dose of water and was wrecked.

I am of the opinion that the water did not come from the condenser; where did it come from? POWER readers have solved other problems put up to them and I hope to read what the engineers who have had experience with condensers think caused the wreck.

H. R. LOW.

Moosup, Conn.

Difficult Packing Job

Owing to an accident to a vertical, compound engine of the riding-cutoff type, it had to have new valve stems, and also new metallic packing. After the engine had again been running a short time the packing began to leak, and gradually grew worse. It was found that the new stems had been made of very soft steel, and the new packing was so hard that it wore a shoulder on the stem.

As the engine could not be spared for some time, a makeshift soft packing was used instead of the metallic packing. First, an asbestos ring packing was used, but it would only stay tight a few days and then the packing would blow out.

Two cup-shaped rings had been used at the bottom of the stuffing box and one between the packing and the gland.

The engineer who had put in the soft packing had taken these rings out and had filled up the stuffing box with the rings of soft packing, depending on the expansion of the packing to keep it tight.

I replaced the cup rings and put three rings of the soft packing between them. When the gland was screwed up in place, it forced the packing into the cups close to the valve stem. As a result there was no more trouble from leaky stems for about eight weeks. There was very little room to put in the packing without disconnecting the stem from the crosshead and taking off the gland, and it was also difficult to keep the rings in place until the gland could be pushed in place.

I drilled a small hole through the rings diagonally, from the side to the middle of the top, on each side of the joint, and put pieces of string in the holes. When the rings were in place the joint was pulled together with the strings and tied. Then there was no difficulty about the rings staying in place.

F. X. GOKHE.

Cambridge, Mass.

Emergency Bearing Repair

Recently in a large power plant in which I was one of the engineers, I came up against an emergency, through the sudden heating of one of the main outboard bearings of a compound engine, which was used for the lighting of the works and a small town in the immediate neighborhood. There was a duplicate set, but it was dismantled and undergoing an extensive overhauling; consequently the other engine was running continuously night and day. It was somewhat overloaded, especially at night, when the full load was on. Ordinarily both engines were in operation from sunset until 1 o'clock a.m., when one was shut down at the end of each run. Both engines were fitted with sight-feed, automatic lubrication; the oil, after having passed through the bearings, was run through a filter, and again circulated by a small pump attached to the engine.

It is impossible to say whether sand or grit got into the bearing with the oil, or whether the oil supply had ceased on that particular bearing, but in any case the engineer noticed smoke coming from the bearing. The throttle was closed, but not entirely, sufficient steam being given to keep the engine turning to prevent the shaft from being gripped.

An examination showed that the babbitting had run out of the bearing and that the shaft at that end was down.

The engine was at once stopped and the bearing stripped, preparations being made for a hurried repair. The 5-inch shaft was gradually cooled by the application of water-soaked waste; and in the meanwhile the old babbitt was chipped out of the top and bottom halves of the bearing, and a pot of white metal got in readiness to run into the bearing. In order to give the necessary clearance when finished, and to prevent the metal adhering to the shaft, a piece of writing paper well greased was tied around the journal. The shaft was then packed up to its original level, and held firmly in its true position by wedges, and the spaces at the ends of the bearing where the metal could run out were closed with red-lead putty faced with oiled paper.

The metal was then poured into the lower bearing until it was filled level to its top. Strips of oiled paper were then laid on each side to divide the metal in the upper bearing from that in the lower, and also to pack up the bearing sufficiently. Metal was then poured into the upper half of the bearing through the oil hole; as soon as the metal set, the oil hole was drilled out and an oil channel cut three-quarters the length of the bearing. The oiled paper was removed, the bearing adjusted, and the engine was started up and the usual load put on it without showing any signs of knock or heating.

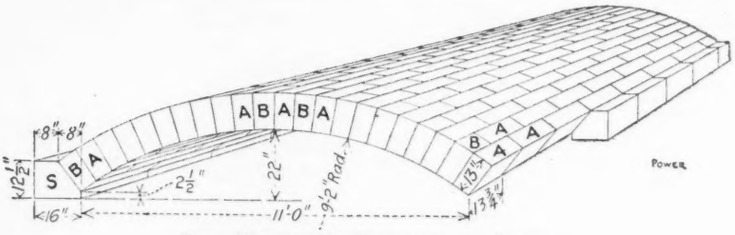
Although the time of stoppage was not taken, I think I am safe in saying that the time occupied in making this repair did not exceed 30 minutes. For emergencies, and indeed at other times, this is a useful method for babbitting bearings in place, but great care should be used to see that everything touched by the molten metal is quite dry and warm; as pouring it upon any cold or damp surface will cause it to spatter.

J. CREEN.

Seattle, Wash.

Bricking Furnace

Furnace repairs are expensive and my experience has shown that the design, workmanship and materials are the cheapest when the best to be had are used.



ONE METHOD OF BUILDING AN ARCH

Boiler settings having large arches cause the most trouble and are commonly found in large power plants.

Many large power stations use automatic stokers with main and coking arches, especially if soft coal is burned.

Furnaces of this type may fail from a high rate of combustion, high furnace temperature and from an inferior quality of firebrick.

Poorly designed furnaces and poor workmanship in building up the furnace affect its period of service. Some of these troubles can be partly overcome, others cannot.

Where a high rate of combustion and high furnace temperature are maintained, any quality of firebrick will fail in time, but if a low grade of brick is used it is not worth the time and expense of putting them in. Such a furnace should

have not less than 13½ inches of firebrick lining and more would probably be better and cheaper in the end.

When clinkers adhere to the side walls they must be removed with the slice bar or sledge. In breaking the clinker off, portions of the firebrick are removed each time and this soon weakens the side wall. If the side wall gives, the arch will either crack or sag. If a side wall has 9 inches of firebrick lining and the balance of the wall is red brick, when the lining is gone and the heat reaches the red brick they crack and melt quickly. I have found it cheaper and better to make the bridgewall and drum arches entirely of firebrick.

Patching up the side walls and joining the new and old work under an arch is not advisable as it is almost impossible to make the work stand.

Any furnace should be heated gradually and cooled in the same manner; cold drafts should not be allowed to pass through the furnace while hot, and leaking tubes on the hot brickwork and arches should not be allowed. Avoiding such conditions will largely prevent the cracking and falling out of the brick at the end and underside of the arch.

I have recently rebuilt 16 furnaces, using the best grade of firebrick. The arches were built up of block, as shown in the accompanying sketch, of the same quality as the brick.

In rebuilding a furnace and laying the side walls all the old wall was removed. The brick in the side walls were uniform in size and quality, were dipped in water and carefully set. The ends of the arch blocks were dressed and rubbed to fit before placing. As much as was practical of the coking arch was laid of blocks, of the same size as the main arch. The balance of the coking arch was made up of brick.

These 16 arches have been in service about nine months and they are in as good condition as when rebuilt.

Previous to building the arches, standard brick were used, and they would sag and fall in from two to six weeks. Some of them were rebuilt three times within the year. These arches have an 11-foot span and 22-inch spring.

In the sketch is shown the construction on the arch I have successfully employed. It is impracticable to build one side of a battery at a time.

To rebuild a battery of this class costs between $600 and $800, including material, labor, etc.

The loss of service of the boilers would depend upon conditions and the number held as reserve units. To operate a battery with fallen arches and bad settings for any length of time causes losses probably near the cost of the rebuilding.

W. J. MAXWELL.

Indianapolis, Ind.

Troubles Due to Carelessness

An industrious oiler, seeing that the temporary shed which inclosed a new 500-kilowatt turbine was dirty, set to work to clean it up, using large quantities of water, but he forgot that the condensing and exciter set was in the cellar. As a result the condenser motor was burned out and the turbine was run with atmospheric exhaust. The night the load came on I had the time of my life. A gang of laborers was set to work sawing wood so that steam could be held, the boilers, to begin with, being heavily overloaded. We got the motor fixed up by working all night on the three coils which had been burned out.

On starting the motor I was unable to prime the centrifugal pump as the foot valve was stuck open. The only thing to do was to rig a scaffold over the well and haul out the 8-inch foot valve and 20-foot suction pipe with the block and tackle.

When that was fixed up I congratulated myself that there was nothing else to go wrong. I had not been running 30 minutes when the turbine began to slow down, due to the fixed and moving blades rubbing.

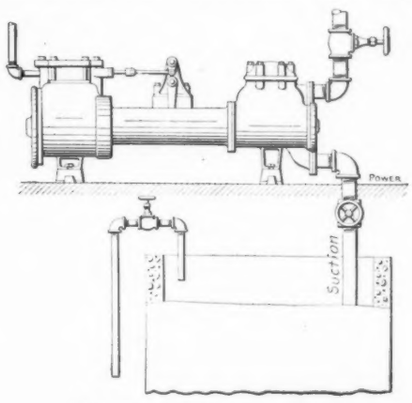
It seemed to be pure cussedness, but the real reason was that the change from atmospheric exhaust and superheated steam to a vacuum was too much for the disks, and they just warped.

H. PREW.

Montreal, Can.

Concrete Compound Tank

I have in my plant a concrete box for holding a boiler-compound solution which was made as follows: A dry-goods box of the proper dimensions was used for the inside form. The outside form was



CONCRETE COMPOUND TANK

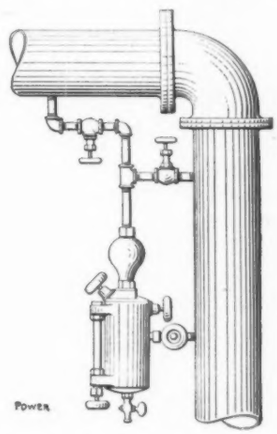
made of rough lumber and was about 4 inches larger than the inside box. The bottom was put in first, and the inside form was then placed inside of the outside form and the space was filled with cement. The mixture was 1 of sand to 1 of cement. Old pipe or iron wire can be used to reinforce the box. After removing the forms a wash of pure cement and water was put on which added to the appearance, and also made it water tight. When placed and piped as shown in the sketch, it is far better than a tub or a barrel sawed in half, as it will not dry out and leak if neglected.

HARRY E. KOFFEL.

Doylestown, Penn.

Auxiliary Lubricator Connection

When an engineer drains a lubricator it is difficult to get it to start to feed at



AUXILIARY LUBRICATOR CONNECTION

once with the ordinary method of connecting.

When an auxiliary pipe is attached to a lubricator as shown, the condenser will be filled while the engineer is filling the lubricator. The reason for this is that there is always some water passing through from the steam pipe on the bottom, which drops out at the first opening. This connection can be put on without changing the ordinary connections or the head of the water.

FRED N. LIVINGSTON.

Seattle, Wash.

Burning Fuel Oil

I received the following interesting letter from H. P. Porter, of La Fundición, Peru, on "Burning Fuel Oil." It may be interesting to other engineers.

W. A. HAMLIN.

Paola, Kan.

Perhaps it may be novel to hear from a Kansan now working among the clouds, 14,000 feet above the sea, in South America.

I read your inquiry in POWER (May 23 issue) about fuel oil. You may expect to evaporate about 10 to 15 pounds of water from and at 212 degrees per pound of crude petroleum. For your case assume 12 pounds of water actual evaporation. If your 55-horsepower engine is fully loaded, it will use probably not less than 30 pounds of water per horsepower-

hour or a total of 1650 pounds of water per hour. To evaporate this quantity of water will require 137 pounds of oil. A barrel of 42 gallons should weigh about 320 pounds and last 2⅓ hours if the engine runs under full load.

I would recommend that you elevate the oil-storage tank so as to get not less than 10 feet of head. A pump would help you in case you do not use an elevated tank. A very small duplex pump will do. It should have a relief valve on the discharge so arranged that it will run the oil back into the suction.

Do not heat the oil unless it is too heavy to run.

H. P. PORTER.

La Fundición, Peru.

Pumping Engine Governor

A vertical, cross-compound, condensing Corliss engine, direct connected to a centrifugal pump, was recently installed in the pumping station where I am employed. The speed of the engine is regulated, on the high-pressure side, by a governor, arranged as shown in the accompanying illustration. It is driven by a chain drive and has a hand adjustment for variable speed and is equipped with an automatic safety stop which is on the back side of the governor column and is shown by the dotted circle it is connected to the steam chest by the pipe *C*.

When the throttle is opened and the governor balls start to rise, the steam pressure causes a lever to lean to one side, which allows the governor to drop to its lowest position in case the chain should break or run off, thereby throwing the safety cams in position and preventing the steam valves from opening. When the throttle is closed and before the governor comes to rest the lever moves to a vertical position and comes in contact with a stud that projects downward from a boss in the slot and prevents the governor from dropping to its lowest position. The low-pressure cutoff adjustment is by hand. It is the duty of this unit to pump water from the river to the settling basins.

One night it was necessary to slow the engine down as the basins were full and the consumption small. When slowing down the wheel *A* was screwed down, which compressed the spring *D* and raised the governor balls higher, making a shorter cutoff. It ran all right for a short time when suddenly it speeded up. I saw that the governor had stopped, and when the engine was shut down it was found that the chain had run off the sprocket wheel on the shaft and the safety stop had not operated. I found that the spring was strong enough to hold the governor balls up, which kept the safety cams from coming into action.

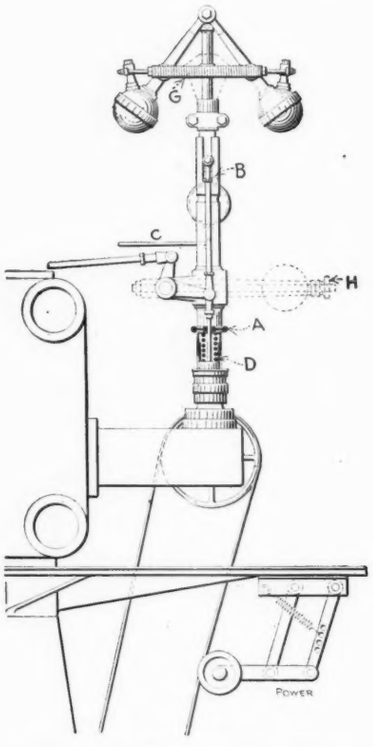
The chain was put on and the engine started and adjusted to run a little faster and it gave no more trouble.

The reason why the engine did not run away when the chain came off was that as the speed increased the pump discharged more water, which acted as an automatic protection to the engine. This would work only where the discharge from the pump is open and with this design of pump.

If it had been pumping direct to the discharge pressure the speed would have increased more than the safety limit and would probably have wrecked the engine. The safety stop would operate when the engine was running several revolutions below its rated speed.

A belt tightener was made and fastened to the ceiling of the gallery as shown. This took the slack out of the belt and kept it from swinging sidewise and running off when the engine ran at slow speeds.

At a certain pumping station there is another unit used for the same purpose but made by another firm. The governor is the same with the exception of the springs *D* and *G*, which are substituted by a lever and weight with a threaded



GOVERNOR OF PUMPING ENGINE

rod and wheel *H* for adjusting the weight on the lever and fastened to the bell crank, also a counterweight, as shown by the dotted outline.

With this arrangement the governor could operate the safety cams at any speed if the belt should run off the pulley or break.

LAWRENCE KJERULFF.

Kansas City, Mo.

Efficient Machinery

If the managers and engineers of steam plants would make a careful inventory of their present plants and put down in black and white the many leaks discovered, they would be surprised at their frequency. One reason why a new plant shows such a high degree of economy is because there are no leaks.

There are many engines, pumps, generators, etc., running today which, if repaired here, had a new valve there and there was less "cussing," would show higher economy. A central-station solicitor is rarely successful in getting well kept plants.

JAMES W. HOCKADAY.

Granbury, Texas.

Avoided a Shutdown

One time on an excavation job I noticed that the key was loose in the flywheel of the large centrifugal pumping set and that the flywheel was working off the end of the shaft.

To stop the pump and drive in the key meant time lost in priming the pump with the facilities at hand, and meanwhile 50 men would be idle.

I picked up a heavy hammer and found that by holding it against the shaft the wheel could not work off any further. I then called a man out of the pit and stationed him at the hammer for three hours and kept things going.

W. CANDLISH.

Edmonton, Canada.

Dry Back Marine Boiler

Would not the internally fired, dry-back marine type of stationary boiler be suitable for small mill and electric-light plants? In some of the small northern plants containing but one boiler it is sometimes necessary to keep the boiler under steam for three months at a time during a cold snap. In plants using the usual return-tubular boiler there is considerable danger of burning, especially if it is necessary to use a boiler compound.

With an internally fired boiler it would be an easy matter to keep scale from forming by feeding the necessary amount of compound, and the sludge so formed would settle under the furnaces away from the heat. By using the blowoff two or three times a day it would be quite safe to run three months without cleaning.

There must be a number of these boilers in operation, and I dare say many of the readers have considerable data on the kind of service they are giving.

I would like to know if they give much trouble, due to poor circulation, and if these boilers would not be satisfactory in sizes up to 150-horsepower or even 200-horsepower units when fitted with corrugated furnaces.

CHARLES FENWICK.

Wapella, Sask., Can.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Hot Bearings

E. P. Baums, in the October 3 issue, page 525, advocates cooling a hot bearing with cylinder oil and water. I have tried this, also graphite and oil, but experience on an air compressor has taught me that lava soap and water is best for cooling bearings.

A few days ago I had to work on an air compressor and had to put some liners in between a bronze bushing to bring it in line. When I got it started it ran hot to the smoking point in just a few seconds. Cylinder oil was poured on in a stream, but did little good, so I stopped the compressor and cut up a cake of lava soap in small blocks and put them in the oil hole and then poured a fine stream of water on the soap. In a few minutes, by the aid of two buckets of water, the bearing was running very well; then soap and oil was used for a little while, and thin ordinary machine oil. Now it runs just as cool as any bearing around the plant.

DANIEL GOULD.

Statesboro, Ga.

Massachusetts License Laws and Examiners

In the August 1 issue, J. E. Levy, under the heading "Massachusetts License Laws and Examiners," criticizes quite severely everybody and everything in general connected with the licensing department of his State. Since then several letters commenting upon the one referred to have been published. I have been quite interested in them, especially the one by Albert A. Smith on page 334 of the August 29 issue.

I believe Mr. Levy is correct in his stated views and if those holding radically different ideas, with a few exceptions, will take a little time and read between the lines in Mr. Smith's letter, they will discover some reasons for Mr. Levy's declaration.

Mr. Smith is quite closely connected with the examining board, he has been present at a number of examinations and it will be noted that those employed in the same plant with him have had no trouble in securing first-class licenses and that one of them has even been appointed inspector.

A little further along I find that he had considerable to do with "House bill 310," to which Mr. Levy makes objections. As Mr. Smith continues in his explanation relative to committee hearings, etc., it sounds good to the uninitiated, but to those who have come in close touch with such matters, the impression he wishes to make is not lasting.

With all due respect to Mr. Smith and those connected with the licensing system of Massachusetts, I smell fish!

A. K. VRADENBURGH.

Albany, N. Y.

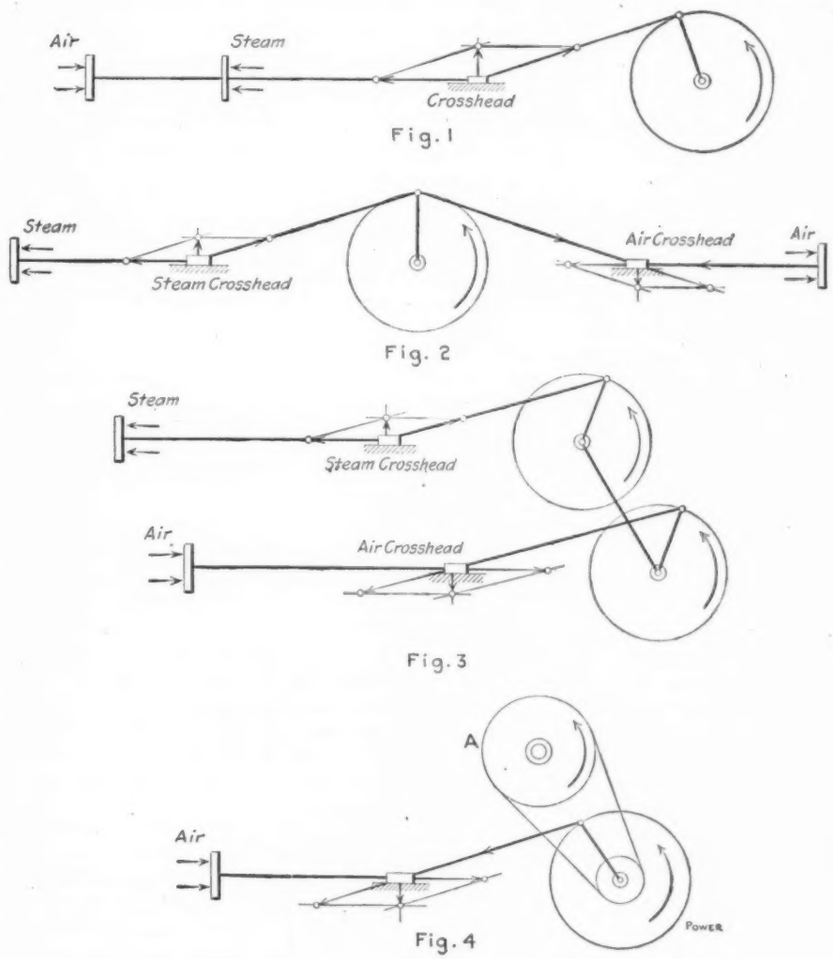
Air Compressor Running Under

The letters which have been published on this subject appear to be rather at variance. In the four illustrations each machine is supposed to be running counterclockwise, and the forces which seem to me to act at the various crossheads are indicated by arrows pointing vertically upward or downward as the case may be. Fig. 1 represents a tandem machine; Fig. 2, two machines facing each other; Fig. 3, a twin machine, and Fig. 4, a compressor driven by the motor or belt pulley *A*.

I may be wrong; if so, I should appreciate a full and correct explanation of where and why.

JOHN S. LEESE.

Manchester, Eng.



DIAGRAMS SHOWING DIRECTION OF FORCES ACTING ON CROSSHEADS

Flywheel Explosion at West Berlin

I was much interested in W. E. Chandler's theory as to the cause of the recent flywheel explosion at West Berlin. According to Mr. Chandler, this wheel was 16 feet in diameter, ran 86 revolutions per minute and was a very good casting. With good cast iron a tensile strength of 18,000 pounds should be a safe allowance. The wheel had a rim joint, probably half way between spokes; giving this joint an efficiency of 25 per cent., and reduces the available tensile strength to 4500 pounds per square inch.

Using the formula for stress, due to centrifugal force, in a pulley rim the bursting speed of the rim would be 256.6 revolutions per minute, or about three times the proper speed of the engine.

A generator operated as a motor will not run at as high speed as when driven as a generator, but it will not make much difference if we assume that it runs at the same speed. The speed varies inversely as the field strength and to increase the speed three times the field strength must be divided by three.

Mr. Chandler was running two machines in parallel and doubtless both machines were connected by an equalizer between the armatures and the series fields. The current driving the motor must have come from the other machine and its path would split between the equalizer on one side and the series field of No. 2 generator, the busbar and the series field of No. 1 generator. This split in the current will be in an inverse ratio to the resistance of the two paths. The resistance of the equalizer would probably be very low and the most of the current should go through it.

It looks very doubtful to me if under these circumstances enough current would pass through the series field to reduce the field strength to one-third of its proper value.

Another thing, if the generator motored, the only load it would have would be the friction of the engine, and this would not require a large current and the ampere turns in the series fields would be proportionally less. For the same reason, a circuit-breaker set at 550 amperes should not go out, although from what I have seen of small railway power plants on holidays I am surprised that the breakers did not go during the day, which, from Mr. Chandler's statement, it seems they did not.

Mr. Chandler believes that the outboard bearing was first torn from its foundation and that the bursting speed was not reached. With the generator running as a motor, the only pull on the belt and bearings is that required to run the friction load of the engine. This would be nothing compared to a load of 500 amperes.

Where then was the strain to tear up this bearing unless the flywheel was badly out of balance? One would not expect it in a plant running every day.

It is always much easier to find flaws in the other fellow's theory than to advance one. With this type of governor, if either one of the gears or the governor pulley should get loose the balls would drop to a position where steam would be taken at full stroke. This would cause the engine to speed up, take on load until the circuit-breaker went out and then—good night!

This might very well happen to a governor with a very careful man, even if he looked it over in the morning. Mr. Chandler states that he went over the wreck carefully, and I do not doubt him.

I very well realize that there is a runaway now and then for which the engineer is not so much to blame as some would have us think. I would be pleased to read the opinion of others regarding Mr. Chandler's theory.

LESTER FITTS.

West Fitchburg, Mass.

Priming of Water Tube Boilers

Referring to the article in the issue of September 19 on "Priming of Water-Tube Boilers," the author seems to have dealt very fairly with the boilers mentioned in the article. While there are a number of makes which were not mentioned, they are all similar to those described with the exception of the Parker boiler, which operates on an entirely different principle from all others, and several details of its construction and operation are of especial interest in this connection.

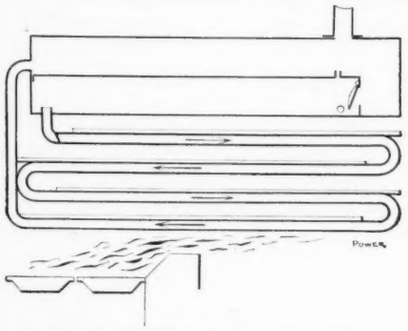


DIAGRAM OF WATER CIRCULATION IN PARKER BOILER

The tubes in the Parker boiler form continuous elements to which the water enters at one end and the steam is taken from the other end through direct upcasts to the drum. There is absolutely no counterflow. The principle of the boiler is shown diagrammatically in the accompanying illustration.

The boiler has a large longitudinal drum, divided by a horizontal diaphragm into separate chambers for steam and water. The upcasts discharge the steam and unevaporated water at the rear of the drum into the steam space in a horizontal direction, and the steam travels about 15 feet through this large passage before reaching the steam nozzle. This affords ample opportunity for the separation of the unevaporated water.

The anti-priming valve between the steam and water chambers prevents priming on a drop in pressure.

PARKER BOILER COMPANY.

Philadelphia, Penn.

The Salesman and the Engineer

I was very much impressed with H. M. Phillips' article, page 516 of the October 3 issue, dealing with the above heading. His statements are well known facts to engineers who come in contact with the salesman. Engineers who are buyers, as a rule, "come from Missouri," and if an article with which they are unacquainted is offered to them, they want to be shown. The salesman offering the article should be thoroughly familiar with his goods in every particular and under all conditions of operation. No one article will operate successfully under all conditions and yet there are salesmen who will talk one off his feet trying to clinch an argument. In my opinion this is poor policy. If a question is asked regarding a certain article as to how it will work under certain conditions and the salesman is entirely ignorant of that condition, he will rarely admit it frankly, but will confidently guarantee success for his goods. These verbal guarantees by some salesmen are, and have been, the cause of a loss of business to manufacturers.

In my own experience I have met a number of salesmen, and in one plant in particular they were all referred to me as soon as they appeared. As I was always on the lookout for anything which would increase the efficiency of the plant, I would listen to their introductory talk which usually included a general description of goods, and in the case of apparatus usually concluded with the usual guarantee (verbally given) of a saving of 10 per cent. in fuel.

Now it so happened that the plants under my charge at the time were new, and I had about as modern and uptodate equipment as could be purchased; in fact, no money had been spared to make them second to none in economical operation and efficiency, and the fact that our daily coal consumption was considerably under 2 pounds per horsepower per hour, shows that they were successful. When a salesman would talk about a 10 per cent. saving in my coal bill, I used to think he was up against a pretty stiff proposition, and I would make my proposal about as follows: "Well, deliver your apparatus, make any and all changes while the plant is not running (which would be at night or Sunday),

furnish all help and tools, have the plant ready to operate at the regular time, and, if the device is not successful, remove the apparatus and leave everything as found, I to be the judge. I will draw a contract to that effect and shall expect your firm to affix its signature. If the 10 per cent. saving is made, my firm will agree to pay the price of your machine and also the cost of installation."

I do not know how many offers and verbal guarantees I had, but I do know that I never found one salesman who would or could get his firm's signature to my contract, and yet if a salesman understood the conditions at a plant he ought to be perfectly willing to do so, if he and his firm really believe they can do what they claim.

WILLIAM N. WING.

Brooklyn, N. Y.

Central versus Isolated Plant

Mr. Bailey hits the nail right on the head in his letter, "Central versus Isolated Plant," in the October 3 issue, as I have found by experience. The principal difficulty, however, is to combat the claims of the central-station agent, as plant owners frequently seem to be hypnotized into being far more interested in purchasing from the central station than in making the proper repairs to their own plant. One of the reasons is the same old story of miscellaneous items of misleading character which are brought up by the central-station agent, similar to the profit ratio.

"Profit ratio" is an item taken up by the central-station agents to justify their claim that they can furnish power cheaper than the isolated plant can produce it, but it is seldom brought forward except where they cannot justify their claims without it. It is very doubtful if central stations could sell power at the present rate if they took the same attitude regarding profit ratio on their own nonproductive plant, as, for instance, their office and power-plant buildings, the distributing system and large purchases of real estate upon which they propose to build in the future. If they put upon these nonproductive items a profit ratio equivalent to the usual profit they obtain from operation, the cost of the power to them and to the user would be greatly increased, as I pointed out in the April 25 issue, where I applied the same profit ratio in a specific case. I have as yet seen no argument advanced by the central-station agent as to why this profit ratio should not be applied to his own case as well as to the isolated plant.

So far as an isolated plant handicapping the manufacturer is concerned, it is entirely a question of how well an isolated plant is installed and with what knowledge and accuracy the estimate of the future possibilities of the business are judged. Even under the conditions of purchased power, there is a great possibility that the manufacturer may underestimate the possibilities of growth, and thereby be greatly handicapped by his location as well as by his power contract.

In the installation of the electric drive with power generated in the plant itself, there is quite as good an opportunity for growth as there is through purchased power. The central station is in many cases no better situated for furnishing power at a low price than is the isolated plant, unless its load factor is of a character which will allow the use of its apparatus continuously for power purposes and the two peaks, power and lighting, not coming together.

If the central station has a load with marked peaks, requiring a very large amount of apparatus during the peak load, and during the average load only a comparatively small amount, the interest, maintenance and depreciation (profit ratio) on this apparatus have to go into the cost of power somewhere, resulting in a large fixed charge which does not enter into the isolated plant. During those periods when the isolated plant requires a small amount of power, which may occur during slack times, the cost of power per unit would increase, owing to the increased fixed charges on the smaller amount of power used; but I notice that the rates on power furnished by the central stations are so arranged that under similar conditions the purchaser has to pay a larger price per unit for the smaller amount of power.

The question is, can the isolated plant, by means of proper installation and operation of apparatus, produce power at a cheaper price than the central station can supply it under similar conditions, the isolated-plant power being figured on the basis of no steam used for heating purposes, and the cost of power as furnished by the central station being figured as the cost of power plus the cost of coal, water, labor and fixed charges on apparatus necessary for supplying the heat?

For the isolated-plant power there should be taken into account the interest on the investment necessary for producing power, the maintenance and depreciation, the value of the room required for producing this power as compared to what it would be worth in case power were purchased, and all operating charges, no attention being paid as to whether the power plant earned a profit on its installation. The profit on this will be paid for in exactly the same way as will the profit on the desks, chairs, and extra fittings for the factory and all labor, not including productive labor, all nonproductive items; in other words, it will be paid for out of the general profits.

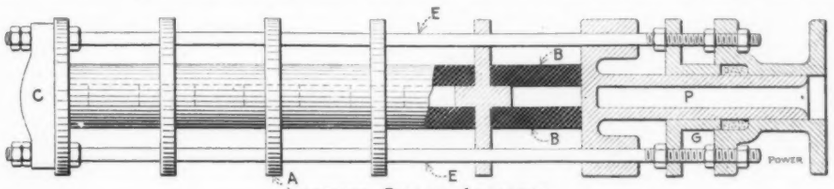
HENRY D. JACKSON.

Boston, Mass.

Shock Absorber

In the September 19 number, H. Prew is perfectly right when he says his idea appears too simple to be new; it is very old.

In the illustration is shown a shock absorber, which consists of a plunger *P* working through a water-packed stuffing box *G*. Springs are arranged on top of the plunger which may be of rubber, as shown, or helical coil springs can be used. The tie rods *E* hold the rubber buffers *B B* in place. The idea is shown and no description is necessary.



ANOTHER SHOCK ABSORBER

JAMES E. NOBLE.

Toronto, Can.

Going over the Chief's Head

Some years ago the writer was firing in a small light and power plant in which it became necessary for the management to reduce the operating expenses of the system. In doing this, several men were dispensed with and the salaries of the superintendent, chief engineers and several other men outside of the station were reduced. The superintendent, chief engineer and assistant engineer quit after a reasonable notice. These vacancies were filled by men from a large station some distance away. The chief engineer was a good talker on the subject of steam engineering, but would not put his knowledge into practice; the superintendent was of the same caliber, but his word could not be depended upon and he tried to do everything in the very cheapest and most haphazard way. The supplies were of the very cheapest and were not ordered until the last minute.

These circumstances made it very difficult to keep the plant in good running order, so it became necessary to go over the head of the superintendent to the general manager for the necessary supplies. Later, a new superintendent came on duty and it has never been necessary to go over his head for anything reasonable. Fortunately, not many incompetent men are on the list, and they usually go the wrong way on the ladder.

C. E. NIGH.

Morgantown, W. Va.

Erosion of Pump Runner

In the October 3 issue of POWER, page 526, John James shows a view of an eroded pump runner with which he has had some experience. I have found similar cases of erosion on the worms of screw pumps which have been in operation for a long time, and have also seen it on other parts of machinery in direct contact with moving water.

I have attributed the erosion in spots as being due to the difference in grain of the metal used in making the moving parts. In the cases referred to I have found spots pitted out, leaving a large ragged, honeycomb-like hole, and the spots in the metal, when broken, showed a coarse, sandy-like grain, but when it was of fine grain it was not affected.

The coarse grain is so porous that the action of water in motion and under pressure works into the pores and oxidizes the particles until they gradually wear away.

The proper remedy for such a case would be to have the runners cast from an even, fine-grained metal. Electrolysis, as I understood it, would attack the stationary part as well as the runner.

L. M. JOHNSON.

Glenfield, Penn.

Jet Condensers

A good suggestion is offered by A. S. Specht, on page 487 of the September 26 issue. He advocates tapping the exhaust pipe close to the low-pressure cylinder and putting in a 1½-inch globe valve as a vacuum-breaker to use should occasion require. My choice is a cock in place of a valve, as one move will pull it wide open.

The incident related in the letter referred to, where the automatic vacuum-breaker failed to work properly, calls to mind a narrow escape from an engine wreck which happened a little over a year ago. The night engineer in a station of 20,000 horsepower reported to his relief when going off watch that he had tried all vacuum-breakers (five in number) and that two failed to work.

All five engines were running with jet condensers of the twin-cylinder, walking-beam type, the vacuum-breakers being operated by the usual copper-ball float. Upon examination of the two breakers which would not work, in one case it was found that the ball had collapsed, and in the other it had split entirely around, filled with water and sunk. The night following the putting in of a new ball float, the bonnet and yoke were blown off the throttle valve of the very engine having the sunken ball float. This accident was owing to a defect in the dashpot of the stop motion on this engine and the valve was slammed down onto its seat with sufficient force to contribute to the effect as stated above.

The engine was of the heavy-duty type, direct-connected, with a heavy generator and flywheel. In order to stop the engine from running away, it was necessary to shut the main stop valve from the header which carried 160 pounds pressure. The layout of the piping was such that both air pump and engine were supplied from the same line; consequently, when the main stop valve was closed the air pump was stopped long before the engine, which was running at 94 revolutions per minute, normal speed. What would have happened to that engine had not the vacuum-breaker been put into good working condition may well be imagined.

H. R. LOW.

Moosup, Conn.

Indicator Diagrams

In looking over some back numbers of POWER, I chanced upon the accompanying diagrams submitted by Mr. Fryant, and originally published in the November 1, 1910, number. A writer in one of the later issues, in discussing these diagrams, expresses the belief that the peculiar expansion lines are due to a grooved cylinder.

This is the reason given by Thomas Pray in his "Twenty Years with the Indicator." Others have ascribed it to the momentum of the indicator parts.

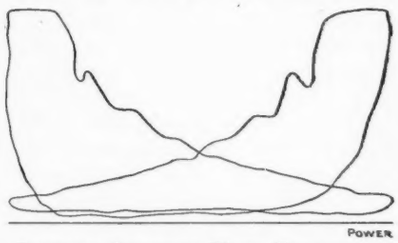


DIAGRAM SHOWING WAVY EXPANSION LINE

There is little doubt that the engine from which the diagrams were taken is one equipped with a main valve, single ported on the face next to the cylinder and triple ported on its other face, where a triple-ported cutoff valve rides. The main valve is actuated by a fixed eccentric, while the cutoff valve is actuated by an eccentric under the control of a governor. This governor is almost purely of the centrifugal type and possesses little stability with which to resist disturbing influences set up by the action of the valves.

The motions of these valves are so correlated that when cutting off early in the stroke the valves move in opposite directions.

At the instant when cutoff occurs the cutoff valve is moving at nearly its maximum velocity while the main valve is either standing still or its motion is just being reversed. After cutoff has been performed the pressure in the cylinder begins to fall by expansion, which creates a difference of pressures acting on the two sides of the cutoff valve, as the port in the main valve is still open to the cylinder. This unbalancing of the cutoff valve causes it to stick firmly to the face of the main valve and its motion is momentarily arrested by reason of the fact that the main valve is either at rest or moving very slowly. This stoppage of the cutoff valve puts a strain on its eccentric which overcomes the stability of the governor, causing the weights to assume an orbit for a later cutoff and when the weights again assume their normal orbit they revolve the eccentric, thus causing the cutoff valve to reopen the ports and admit more steam to the cylinder. I can distinguish five points of cutoff on the diagrams shown herewith. The admission of steam in this manner is not only very wasteful, but it must seriously affect the regulation of the engine.

I believe that this condition could, in a measure, be overcome by putting a drag on the cutoff eccentric, in the shape of a double-acting dashpot, or by fastening to it a heavy inertia bar.

The first would overcome the tendency by holding the eccentric in its proper position until the critical point was passed, while the second would acquire momentum tending to pull the eccentric against the resistance of the unbalanced valves, but I doubt that either remedy would entirely eliminate the trouble, as the drag of the valve extends until the cutoff of the main valve occurs and it will become greater as expansion proceeds.

It is possible that more copious lubrication would also tend to smoother operation of the cutoff valves. I would advise that Mr. Fryant try this, and, if it has a beneficial effect, not to be saving of his oil, as the saving at the coal pile would in all probability more than pay for the quantity required.

CHARLES F. PRESCOTT.

Philadelphia, Penn.

Nerve

Judging from Mr. McEnaney's statements in his letter in the August 29 issue, the engine under discussion must have been of the Corliss type. If that was the case, it would be interesting to many engineers to know just how he was able to reach and "hold up the blocks or hooks" without losing a finger or two, possibly a whole hand.

If the means adopted by Mr. McEnaney were necessary in order to save the engine, it is plainly evident that the governor was not properly adjusted, as it should have brought the engine to normal speed, by doing practically the same thing as he did. If it would not do so then an engine thus equipped would have a very brief career as a rolling-mill engine, for manifestly an engineer could not "hold the blocks up" every time a billet passed through the rolls.

JOSEPH STEWART.

Hamilton, O.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 30,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Rate Discrimination

The question of rate discrimination, alleged to be practised so extensively by the New York Edison Company, now promises to be brought to an issue.

As announced by us at the time, several months ago a petition bearing the signatures of several hundred consumers and backed by the representatives of several prominent engineering societies, was presented to the Public Service Commission for consideration. This petition charged that nearly one-half the electric current sold by the New York Edison Company in Manhattan and Bronx is charged for at a rate over three hundred per cent. greater than the average rated charge for the remainder. It was pointed out that a large part of this current is sold below cost (including fixed charges) and that the small consumer, paying nine and ten cents per kilowatt-hour, is obliged to carry the burden of the fixed charges resulting from this discrimination. In relief of these conditions the petition asks that rates be established whereby all consumers shall contribute fairly and equitably to the charges and profits of the business and that discriminatory rates be prohibited; in other words, that a maximum and minimum rate be established, the difference between which shall repesent merely the physical difference in the cost of producing in small and large quantities.

The first public hearing in answer to this petition was held before Commissioner Maltbie on Monday morning, October 23. Little was done at this meeting save establishing the fact that the Public Service Commission had jurisdiction in the subject at hand, and in outlining the method of procedure. In the latter connection it was decided that a definite case should be selected upon which to base the charges of discrimination, and thus avoid introducing too many generalities. In order to afford an opportunity for both the complainant and the respondent to prepare their cases, the hearing was adjourned till 2:30 p.m., Wednesday, November 1.

The attorney for the New York Edison Company admitted the rates as set forth in the petition but denied that they were discriminatory or that current is sold for less than cost.

In commenting upon this attitude it may be explained that the New York Edison Company, like most central stations, contends that inasmuch as it is obliged to maintain equipment of a certain capacity to supply its large number of small consumers, who use power only part of the time, it can supply a number of large consumers during certain hours without extra cost except for the fuel and water used. Upon this basis it is contended that current is not being sold below cost but that a profit is actually being made. Of course, the fixed charges are borne by the small consumer.

In contrast to this attitude it will be recalled that in a recent discussion upon "Central Station versus the Isolated Plant," a certain New York Edison representative insisted that a high rental rate be charged to the isolated plant for the space occupied in the basement of a building; yet the basement was there as a necessary adjunct to the rest of the building.

It seems hard to reconcile these two diametrically opposite attitudes regarding questions involving the same principle.

Generally speaking, why should gas be treated differently from electricity? They are closely analogous, both in production and distribution; yet gas is paid for at eighty cents a thousand cubic feet whether the consumer uses one or fifty thousand cubic feet.

The demands made in the present instance have precedent in the decision of the Wisconsin Railroad Commission in the case of the Menominee & Marinette Light and Traction Company. Here the commission fixed not only a maximum rate for light and power, based upon the hours of service, but also a minimum rate of 4½ cents per kilowatt-hour. In this connection the following is quoted from the decision of the commission:

"To put a rate schedule into effect for permanent use, which is so low as to hardly cover the output costs or that yields so little in the way of revenues as to leave little or nothing for interest, depreciation and taxes, would seem to be out of line with sound business practice and discriminatory against other customers."

Again, in the report of the Public Service Commission for the second district of New York State, is to be found the statement:

"Until June, 1910, the jurisdiction of this commission over rates enforced by gas and electric corporations was limited, so far as concerns express statutory provision, to investigate and determine upon complaint the maximum price to be

charged. In that month there became effective, by an act of the legislature, amendments to the Public Service Commission law by which the general and specific powers of the commission were greatly enlarged.

"That the question of just and equitable rates was not to be solved in the exercise alone of the authority to fix the maximum price, and that there exist broader and more fundamental problems to be dealt with, is now regarded in these amendments."

Then follow some long extracts from the amendments which in principle affirm the contention that not only a maximum but also a minimum rate must be prescribed in the schedule of rates.

Graft

We are in frequent receipt of letters from engineers expressing indignation against the charges of graft now so often appearing in the trade press and in engineering assemblies; that they are dishonoring a body of men who are of strictest probity; that such charges are undoing the uplift for which so many engineers are earnestly laboring.

These contributions would be unanswerable if there were not enough truth in the charges of graft to make the whole question too serious to be ignored by anybody who is interested in the well-being of the engineer.

There has been no charge that grafting is universal. There are many engineers who are unapproachable with bribes and above the taking of tips. The reproaches which are being heaped upon the practice are not for them. Let the galled jade wince.

The honest engineer may find it hard to remain silent under an inculpation of his vocation which he considers may involve him by implication, but if he must speak let his voice be raised in condemnation of the practice, not in condemnation of the exposure of it. The way to get rid of a festering growth is to cut it open, expose and purge it, not to cover it up with absorbent cotton and scented talcum.

We have learned that one letter received by an advertiser bursting with virtuous indignation at the graft charges published in one of his advertisements was inspired by a competitor of the advertiser.

We have seen a salesman go forth like a paymaster with his pockets full of little envelops each with its monthly "perquisite" for one of his customers.

We have heard salesmen discuss engineers with regard to their degree of approachability, referring to them as "straight," "cheap," "comes high," "takes his," etc.

The practice of grafting is not confined to the vocation of engineering, but POWER is. It is our concern to criticize and condemn anything which militates against the standing and progress of the power-plant engineer, and it certainly does put him in an equivocal and humiliating position to accept perquisites, especially in the shape of money, upon the supplies which he purchases for his employer. Any employer who detects such a practice would be justified in summarily dismissing the engineer, ordering the salesman off the premises and tabooing the further use of his goods if anything else can be had which will do; and there usually can, for real and exclusive merit does not need to buy its way in nor have to pay to stick.

It is good law in this country that every man is innocent until he is proved guilty, but in common, everyday practice suspicion of wrong often places an honest man in a position where he is compelled to prove his innocence.

Conditions are such today that reputable manufacturers and owners are beginning to doubt the honesty of engineers whose records are clean and above reproach.

The honest engineer should disabuse his employer and the business public of this opinion, and it can be accomplished by every reputable engineer treating with disdain the salesman who offers graft, refusing to use the products of manufacturers who authorize it and making it so hot for the grafting engineer that he will be compelled to turn honest and self-respecting if he would continue in a vocation which as a whole stands for honesty as well as skill and intelligence. Expose graft often enough and strongly enough and it will die of sunstroke.

Suction Pipes for Pumps

When pumps are installed with long suction pipes the rise or slant of the pipe from the source of supply to the pump should be continuous if satisfactory operation is expected. If there is a vertical rise in the pipe and then, as is often the case, a descent to the pump, the elbow or bend at the highest point and the length of more or less approximately horizontal pipe forms an air chamber or pocket which is sure, even with the use of a foot valve, to cause much trouble.

If the volume of air trapped in the pipe is large as compared with the piston displacement, it may be found impossible to start the water because of the inability to discharge this air through the pump. There is a great difference between the air caught in the suction pipe and that in a purposely designed suction chamber placed on a riser or tee on the top of the highest point in the pipe. The stream of water in the suction pipe, if long, must not be started or stopped suddenly and the suction chamber is a vessel into which the water may flow continuously during the period of the reversal of the motion of the pump piston.

All water holds air or other gases in solution in proportion to the pressure, and under the reduced pressure in the suction pipe some of the air escapes and collects where the pressure is lowest.

It is therefore necessary for the successful operation of all pumps having long suction pipes, that the pump be placed at the highest point in the length of the pipe, and that the pipe have a continual if not uniform rise from the well end of the pipe to the pump.

There should be an air chamber on the discharge side of the pump as well as on the suction side, as a volume of confined air forms an elastic cushion against which the intermittent action of the piston is transformed into a steady flow. Air chambers, particularly on boiler-feed pumps, should be so arranged as to catch all the air coming along with the water and prevent its traveling onward into the boiler where it aids corrosion.

The sufferers by the failure of the Austin dam are determined that there shall be a searching investigation into the cause of the disaster. A citizens' movement has been organized, counsel engaged and coöperation with the authorities undertaken. This is as it should be. If the failure was an unavoidable, unforeseeable accident, those who are being inculpated for it should be cleared of responsibility and reproach. If the weakness of the dam was evidenced in advance and somebody took chances on it just to keep up dividends, somebody ought to get the same treatment which the man who runs a boiler known to be weak until it explodes ought to—and usually does not—get.

Rhode Island coal is being mined in considerable quantities and sold in the natural state and briquetted for domestic use. A circular recently issued says that the company is turning out about 150 tons of briquets a day, that all the steam for the different boilers at the mine is generated from Rhode Island coal and that 1912 will see about a thousand tons of coal a day outside of the briquets being prepared daily.

Our skepticism regarding the value of the treatment with a homeopathic dose of calcium chloride has turned out to be well founded. The coal has been found to burn just as well without it.

New York's long immunity from boiler explosions has finally been broken. An explosion has just occurred in Manhattan. With the exception of the explosion in Brooklyn a year ago, Greater New York has been remarkably free from disasters of this kind.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Evaporation and Condensation

The condensation returned to the boiler at 212 degrees is 712.27 pounds per hour, which gives

$$\frac{712.27}{30} = 23.74 \text{ boiler horsepower}$$

The evaporation is 10 pounds of water per pound of coal, and 3½ pounds of coal are burned per boiler horsepower developed. But

$$23.74 \times 3.5 = 83.09 \text{ pounds}$$

of coal required per hour and

$$\frac{712.27}{10} = 71.22 \text{ pounds}$$

of coal per hour. Why do these results not check?

B. H. P.

A boiler horsepower is 30 pounds of water evaporated from feed water of 100 degrees into steam of 70 pounds pressure. This is equivalent to

$$(1179.8 - 67.97) \times 30 = 33{,}355 \text{ B.t.u.}$$

the difference between the total heat of a pound of steam at 70 pounds pressure and the heat already in the pound of water at 100 degrees multiplied by 30. The values used are those of the new Marks-Davis tables. If 712.27 pounds of steam are made per hour at, say, 100 pounds absolute, from the returns at 212 degrees, it will take

$$\frac{(1186.3 - 180)\ 712.27}{33{,}355} = 21.49 \text{ boiler horsepower}$$

The 1186.3 is the total heat of steam of 100 pounds pressure, the 180 the amount of heat in a pound of water at 212 degrees. If the pressure were different there would be some other value than 1186.3 for the total heat and the horsepower would be different. The statements that there is an evaporation of 10 pounds of water per pound of coal and 3.5 pounds of coal are used per boiler horsepower are interdependent. If a boiler horsepower is 33,355 B.t.u. and it takes 3.5 pounds of coal to make it, then each pound of coal must furnish

$$\frac{33{,}355}{3.5} = 9530 \text{ B.t.u.}$$

If these evaporate 10 pounds of water, each pound of water absorbs 953 B.t.u.

If the feed water is at 212, in which case the heat already in it will be 180 B.t.u. the total heat of the steam which is making must be

$$180 + 953 = 1133 \text{ B.t.u.}$$

which is true only of steam at less than 6 pounds absolute pressure.

If steam of 100 pounds absolute pressure is made, having a total heat of 1186.3 B.t.u. per pound and only 953 B.t.u. are used per pound to do it, the feed water must have

$$1186.3 - 953 = 233.3 \text{ B.t.u.}$$

in it, in which case its temperature would be about 265 degrees. The assumptions, 10 pounds of water per pound of coal, 3.5 pounds of coal per boiler horsepower, do not agree, except under particular conditions of steam pressure and feed-water temperature.

Size of Cast-iron I-beams

What should be the size of a cast-iron I-beam 12 feet between supports and supported at both ends; the beam to carry a uniformly distributed load of 10 tons?

W. H. W.

The size of I-beam to be used may be found from the formula:

$$\frac{bh^3 - 2\,b_1h_1^3}{6\,h} = \frac{Wl}{8\,p}$$

where,

W = Distributed load in pounds;
l = Distance between supports in inches;
p = Allowable tension in pounds per square inch;

and b, h, b_1 and h_1 represent the dimensions shown in the accompanying sketch. Here $b = 7$, $h = 20$, $b_1 = 3.2$ and $h_1 = 18.8$.

The expression $\frac{bh^3 - 2\,b_1h_1^3}{6\,h}$ is known as the section modulus; it is dependent entirely upon the size and shape of the beam and its values for various beams are given in the handbooks of the steel companies, such as Cambria and Carnegie.

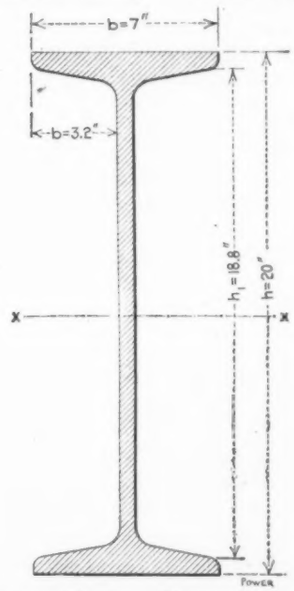
Assuming an allowable tensile stress of 3000 pounds per square inch, and substituting in the foregoing formula

$$\text{Section modulus} = \frac{20{,}000 \times 12 \times 12}{8 \times 3000} = 120$$

From the steel companies' handbooks a 20-inch, 70-pound I-beam is found to have a section modulus of 122. A 12-foot beam of 70 pounds to the foot would weigh 840 pounds. Adding this to the distributed load and solving again for the section modulus, we have

$$\text{Section modulus} = \frac{20{,}840 \times 12 \times 12}{8 \times 3000} = 125$$

A 20-inch beam with a section modulus of 122 would be sufficient if the cast iron of which it is made can be depended upon and if the assumed tensile strength and factor of safety fit the conditions.



SIZE OF 20-INCH, 70-POUND I-BEAM

Since the depth of this beam is more than $\frac{1}{20}$ of the span, the deflection may be neglected. Furthermore, the cross-sectional area of the web is about 10 square inches (it being customary to consider only the web when figuring the shear). This would mean a maximum shearing stress of about 1000 pounds per square inch. But as 5000 pounds may be allowed with safety for cast iron in shear, this stress may be neglected. Hence the only factor to be considered is the maximum bending moment, by which formula the size of beam was found to be 20 inches.

If steel were employed instead of cast iron, a 10-inch beam would carry the load.

The failure of an engineer in a New England brewery to close a valve caused the blowing away in a few minutes of $25,000 worth of ammonia gas. After the gas had begun to flow it was impossible to get near enough to the valve to close it.

Refrigeration Department

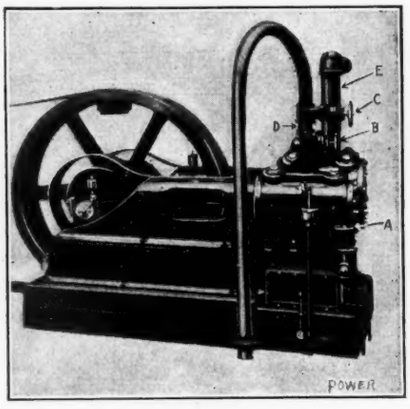
Principles and operation of ice making and refrigerating plant and machinery

Protecting the Compressors

By H. H. Delbert

During the month of September we had an accident to one of our compressors from the same cause as the one cited by Mr. Schindler in the August 22 issue. If I had given Mr. Schindler's suggestion more consideration when I read it, I would have saved the company some money. Hereafter articles appearing in Power, especially those pertaining to accidents and new devices, will receive more consideration from me, and I will try to benefit by them.

The photograph clearly shows the piping on my compressor, with the exception of the unloading device which is on the opposite side of the low-pressure cylinder on the intake pipe *E*. The long bend is the discharge connected into the main line under the floor. The unloader is also connected to the main line under



Arrangement of Piping to Compressor

the floor, and it will not act until there is the required pressure in the main line. On the day of the accident the second engineer started this unit. As had been his habit, he closed the relief valves *A* and *B* before opening the main valve *C*. Before he could reopen any of the valves that part of the high-pressure cylinder above the cylinder proper was blown off and pieces of iron thrown all over the plant. That no one was killed or even injured was almost a miracle. After putting on a new cylinder, I tapped a hole at *D* and to it connected the unloader so that it would act as soon as the pressure was high enough, regardless of whether the main valve was open or shut. This arrangement works very well and I think it is better than a safety valve.

Our unloaders are balanced with a weight, and by sliding the weight back on its lever the unloader will operate at a low pressure.

I am of the opinion that I am not the only reader who has neglected to give articles in Power as much consideration as they deserve, and I hope that this article will be the means of causing every one of them to more fully benefit by the good suggestions and devices shown from time to time, and not wait for an accident to wake them up as I have done.

Cooling Hot Liquor

By George H. Handley

An interesting experiment was tried recently of trying to cool boiling liquor through circulating from one tank to another and at the same time discharging cold air into the bottom of the tanks. The liquor in question was boiled in tanks of 1500 gallons capacity. As it usually took about three days to cool down sufficiently to use and then had to be pumped from the boiling tanks to the main supply tank, the following experiment was tried to cut down if possible the time necessary to cool and at the same time thoroughly agitate the liquor:

A small air compressor was belted to the main shaft and air was compressed into a tank to a pressure of 150 pounds. From this a pipe led into a large coil, this coil being placed in a tank from which water was constantly being drawn off and replenished for mill service. The water in this tank cooled the compressed air to normal temperature. After the air left the coil it was led to a small vertical steam pump and was used for power to drive the pump. The exhausting air was naturally expanded and was carried to a large pipe placed into the bottom of the boiling tank, this pipe being drilled with a large number of 1/32-inch holes which liberated the air to the atmosphere through the liquor. The pump meanwhile was pumping the liquor from one boiling tank to another through a system of by-pass valves and after it cooled sufficiently the liquor was in turn pumped over to the main supply tank.

While the installation gave satisfaction inasmuch that the liquor was cooled off in about 24 hours, still a later installation of an ice machine has proved more economical from a running-cost standpoint.

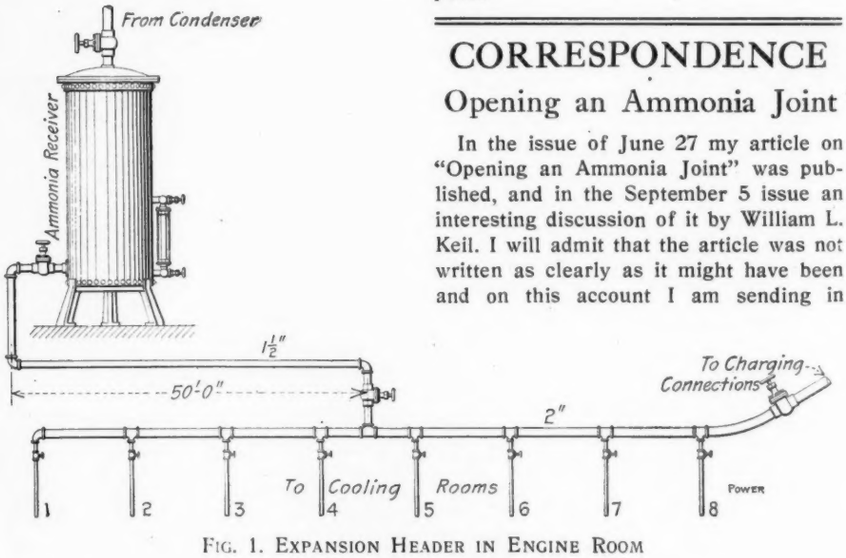


Fig. 1. Expansion Header in Engine Room

CORRESPONDENCE

Opening an Ammonia Joint

In the issue of June 27 my article on "Opening an Ammonia Joint" was published, and in the September 5 issue an interesting discussion of it by William L. Keil. I will admit that the article was not written as clearly as it might have been and on this account I am sending in additional details which will help to clear things up.

I have five branch cold-storage plants to look after and, of course, am very busy. The engineer who operated the plant days was a new man, but from his talk and actions I considered him "well up" on ammonia and did not question him when he claimed that he had pumped

out the coil properly. Pumping out was usually done with a reserve compressor No. 2. I was in the engine room, 50 feet away, when I heard the explosion, due to opening the joints, and rushed into the cooler, where I found the conditions as previously described. I got the engineer out quickly and later found the valve on No. 4 coil one-half turn open and the valve on coil No. 5 had been closed tightly, although I did not know it at the time, for in the excitement the helper had opened No. 5 again as he at once realized that the engineer had closed the wrong valve and wanted to save him if possible. The engineer acknowledged later on that he might have started to close No. 4, but in talking had probably taken his hand from the valve for an instant and in taking hold of the valve again had got No. 5 instead and closed it. Strange that he should not have noticed the pressure rising on the gage. I lost possibly 20 pounds of ammonia. The fan which is used for winter ventilation was started and within three hours everything was restored to normal. There were three low-pressure gages and two high-pressure gages in use and no reason existed for a blunder of this kind, but the human element must be considered.

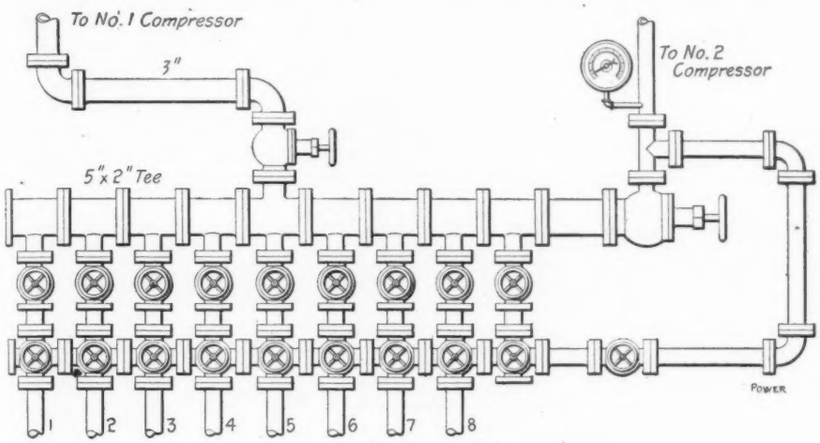


FIG. 2. SUCTION HEADER IN ENGINE ROOM

Fig. 1 gives details of the expansion header in the engine room, Fig. 2 shows the suction header and Fig. 3 indicates the change made in the coil in the lower cooler.

D. L. FAGNAN.

New York City.

A Case of Frost

Where I am employed we have a four-ton De La Vergne tandem ice machine. It was customary to carry frost clear down to the machine and on an average thirty 300-pound cakes of ice were pulled in 24 hours. This was all we could possibly make. This summer, when we were rushed for ice, the manager suggested that we experiment a little with the expansion valve. This was done, and when the frost would get down on the machine, we would close the valve a little. The frost would then melt off, the valves would stick and it would be half an hour before we could get them to work normally. The result was a rise of one degree in the freezing tank. After that we kept the expansion valve open enough to get frost on the suction pipe coming from the freezing tank and did not allow frost to get on the machine. When the frost started to melt from the pipe just outside of the tank the expansion valve was opened a little and when we got dry, or live, frost the valve was closed a little. The valves on the machine never stick any more and we have increased the capacity of the machine from thirty 300-pound cakes of ice in 24 hours to 38. A freezing temperature of 16 degrees is maintained with the compressor running at 90 revolutions per minute.

ANDREW BLAIR, JR.

Norborne, Mo.

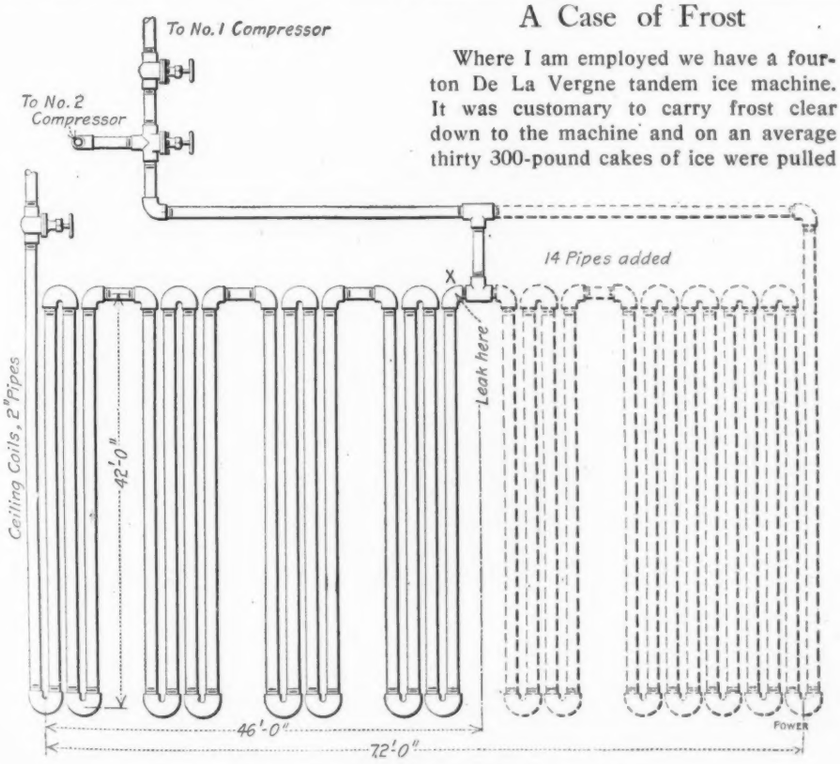


FIG. 3. CHANGE MADE IN LOWER COOLER

Porous Brine Pipes

Some time ago a 10-ton absorption machine of which I had charge was losing the brine at a very rapid rate without leaving any sign of where it was going. The covering of the return pipe, which was 2-inch wrought iron, was of hair felt and tarred paper applied in layers until it took on the appearance of a 4-inch pipe. The inlet was covered with heavy cork insulation with all its joints sealed with asphaltic compound.

The brine in the tank could not be kept at a uniform level under any circumstance and it kept us busy adding calcium chloride and water. To get at the bottom of the trouble, we removed the tank and tested it for leaks. Having satisfied ourselves that the tank was tight, we uncovered the brine pipes. The canvas covering on these pipes was heavily painted and the minute we stuck a knife into the canvas we were deluged with brine. Having removed all of the covering, we found the pipe to be quite porous; it was possible to push a nail through almost any part of the pipe. This condition was in all probability brought about by the alternate freezing and thawing of the condensation on the pipe.

All the piping was removed and galvanized pipe and fittings substituted, with the result that for five months we have been able to keep the brine at a constant level and density. I think that it would be good practice to use more galvanized pipe and fittings in the brine apparatus and less of the black pipe.

H. H. BURLEY.

Brooklyn, N. Y.

Fatal Flywheel Explosion at Baltimore

Waste catching in the gear wheels of a throttling governor caused the engine to speed up and wreck its flywheel.

The flywheel of a duplicate engine was also wrecked and a number of steam and water pipes were severed.

An engineer was scalded to death by escaping steam.

On Monday afternoon, October 16, an accident occurred at the power plant of the Consolidated Gas, Electric Light and Power Company, Westport, Md., which resulted in the death of the engineer and the scalding of two other men by escaping steam. The fatality was caused by the fragments of a bursting flywheel severing two 4-inch pipes which branched out from a 6-inch auxiliary steam pipe.

The flywheel belonged to a small vertical steam engine direct-coupled to a 12-inch centrifugal circulating pump which was located in the basement. This unit serves the barometric condenser which was connected to one side of a 5000-kilowatt, twin, angle-compound main-generating unit. A duplicate circulating unit served the condenser used with the other side of the main engine.

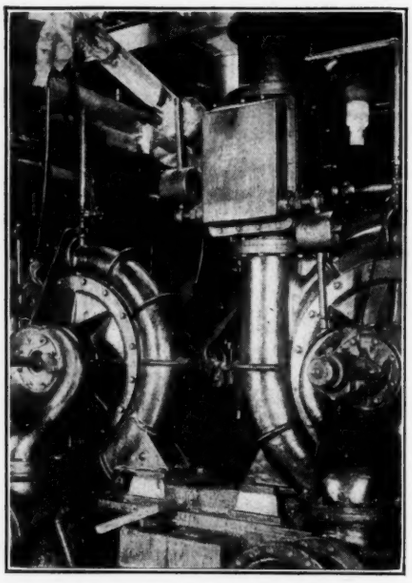


FIG. 1. BROKEN FLYWHEEL SHOWN BACK OF THE TWO CENTRIFUGAL PUMPS

Both of these auxiliaries were set in a concrete compartment, formed on three sides by the foundation of the main engine, the other side of the compartment being open to the basement. The engines were set next to the end wall of the compartment, with enough space to get around them, and a passageway was provided between the two units and between each unit and the side wall. A view of the two pumps is shown in Fig. 1.

The large engine was not running at the time of the disaster, and Engineer William H. Messick, who was killed, assisted by two others, was at work on the small engine packing the throttling-governor valve stem and making adjustments.

It is not known what Messick was doing just prior to the accident. He was, however, standing on the guard over the flywheel of the engine on which he was employed, which would bring him at a convenient working level with the governor on which he was probably working. His assistant was on the floor in the rear at or near the extension throttle-valve stem.

It seems that the engine had been started and was evidently running at full speed, for after the accident occurred the throttle valve was found open about ½ inch, and a bunch of waste was tightly wedged between the governor gears, as shown in Fig. 2. This waste was doubtless the direct cause of the accident. How it got there is not known, but the chances are that it was in the hands of Messick and was accidentally drawn in between the gears, which prevented the governor from operating.

The governors on both engines were fitted with a safety stop, but a precautionary arrangement to guard against a shutdown had been applied to each. This consisted of a piece of iron bent in channel form, the side ends of which were attached to the floor beams above. The bottom part of the channel iron was drilled and tapped for a V-pointed adjusting screw, the pointed ends of which fitted in the countersunk hole at the top of the governor stem. This adjusting screw was set so that the governor could not throttle the steam supply entirely should the governor belt come off, but would give the engine enough steam to supply sufficient circulating water to keep the main engine running under a vacuum.

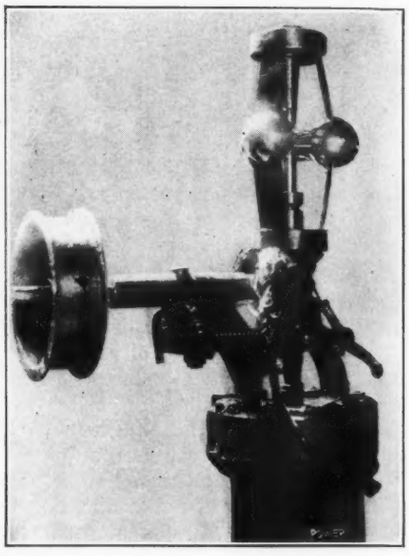


FIG. 2. BUNCH OF WASTE IN THE GOVERNOR GEARS

It is not known whether the adjusting bolt had been changed or whether the centrifugal pump had lost its water, or both, but such a combination of events would, with a clogged governor, have been sufficient to cause the engine to run away.

FIG. 3. FRAGMENTS OF THE FLYWHEELS, BROKEN PIPES AND WRECKED GOVERNOR OF IDLE ENGINE

When the flywheel burst it not only severed the two 4-inch steam pipes, but

fractured a 16-inch condenser discharge pipe and demolished another of the same size, besides wrecking the flywheel of the idle circulating-pump engine and also smashing the bearings of the idle pump. Being confined in the concrete chamber, the rims on both flywheels were broken into fragments, as shown in Fig. 3.

With the breaking of the two main steam pipes, the pump compartment was instantly filled with steam at 175 pounds pressure. Messick was caught before he could escape, and when found was lying between the idle engine and the wall with a lacerated scalp and was badly scalded.

The main engine escaped injury and the total monetary loss will be small.

Boiler Explodes under Sidewalk

New York City was the scene of a remarkable boiler explosion which occurred at midnight on Friday, October 20, when one of two return-tubular boilers which were located under the sidewalk exploded. These boilers supplied steam for the ammonia compressors of the Greenwich Coal Storage Company, 402 Greenwich street.

FIG. 1. REAR END OF THE BOILER AND PROJECTING TUBES

The exploded boiler was built in 1888, and was 15 feet long and 60 inches in diameter. The shell was made of ⅜-inch steel; the heads were ½ inch thick and contained eighty-two 3-inch tubes. The boiler was tested June 6, 1911, at 120 pounds hydrostatic pressure and the allowable working steam pressure was 80 pounds per square inch. The boiler was equipped with a ball and lever safety valve.

Such examination of the shell as is possible in its present position and surroundings, shown in Fig. 1, does not reveal that the sheet has been distorted by excessive pressure, and, so far as can be seen, the shell is intact with the exception of being crumpled at one end and bent along its side, due to striking obstructions in its flight of approximately 150 feet under the sidewalk.

The 3-inch tube pulled out of the front head first. This head was flanged out and when the tubes gave way the head bulged outward about 6 inches.

The 3-inch tubes pulled out of the front and rear heads, but were not flared or beaded. As the tubes drew out of the front head the pressure within the boiler bulged the rear head some 6 inches or more, and the stays which braced the rear head above the tubes were fractured or pulled apart. Several braces at the front head of the boiler were also broken.

About a dozen tubes were blown clear of the boiler, but most of them were forced partly out through the rear head by the force of the pressure or by impact as the boiler crashed into and through obstructions, coming to rest against the street abutments, as shown in Fig. 1, and crumpling the end of the rear course of the boiler shell as if it had been so much cardboard.

The explosion wrecked the basement and front of the building immediately fronting the boiler room and tore up the sidewalk for a distance of about 150 feet, throwing the heavy flagstones, weighing hundreds of pounds, out of place and leaving the basement filled with débris, as shown in Fig. 3. The second boiler, which fronted the exploded one, was not moved from its setting, but the brickwork is considerably damaged and the sidewalk above it has caved in, practically ruining the setting.

The exploded boiler in its flight under the sidewalk passed through a 3-foot

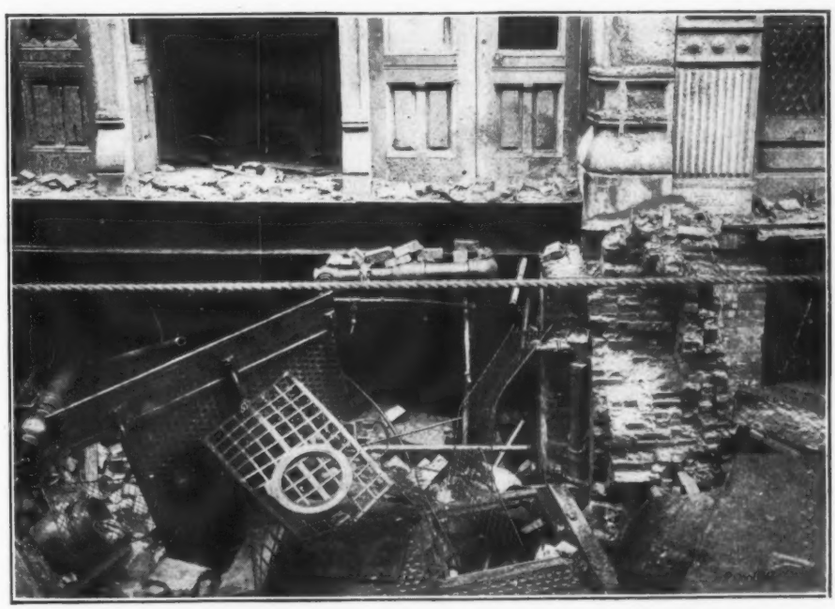


FIG. 2. WRECKED BOILER ROOM UNDER THE SIDEWALK AND BRICK WALL WHICH THE BOILER DEMOLISHED

brick partition wall and also wrecked the water and gas mains. The broken water main flooded the basement and the escaping gas caught fire, which was soon extinguished. One piece of the flagstone severed a girder of the elevated structure above, when it was blown from the sidewalk. The ammonia pipes in the cold-storage plants were broken and the fumes made the work of searching for the injured difficult.

Twelve persons were more or less injured, the most seriously being a policeman who was standing on the street corner. One leg was broken by a flying tube and he was badly bruised.

A representative of the company stated that the engineer, who did his own firing, was in the engine room with several other workmen when the accident occurred. None was seriously injured.

This is one of the most remarkable boiler explosions which has ever occurred in the city of New York, and it is most fortunate that it happened when the streets were practically deserted. More details as to the direct cause of the explosion may be brought out at the trial of the engineer, who has been arrested charged with criminal neglect.

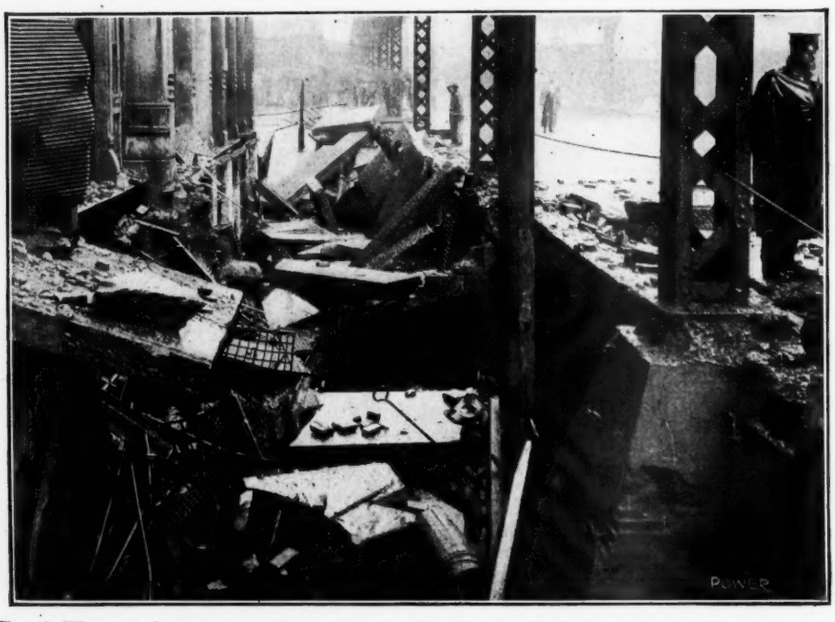


FIG. 3. WHAT IS LEFT OF THE SIDEWALK. THE BOILER IS SHOWN AT THE EXTREME END

Lubricants Used in Canal Equipment

BY DON E. ERWIN

The extensive canal, floating and plant equipment necessary to carry on the construction of the Isthmian canal has compelled serious study of the lubricating conditions by the canal engineers.

As defining in a general way these conditions, the following description of the kinds of lubrication, the manner of receiving it and its distribution and use will be of interest:

There are 21 kinds of lubricating, illuminating and miscellaneous oils and greases in use, of which ten are lubricating, two illuminating, four miscellaneous oils; and five are greases.

All lubricants and oil are standardized as follows: valve, air-compressor, cylinder, marine, stationary, locomotive, turbine and gas-engine oils; crank-case, car, transformer, lard, ammonia, cylinder and crude oil. Greases: nonliquid oil, cup, gear, cable and crank pin. Illuminating: signal and kerosene oils; gasolene.

Of these oils, 12 are received by the commission in 50-gallon steel drums, and three in cases of two 5-gallon cans each. Three kinds of greases are received in barrels and two in 25-pound cans. Crude oil is supplied to the different points in containers convenient for the work required, drawn from the crude-oil tanks located on the isthmus.

The approximate monthly consumption and use of each grade by the commission and the Panama railroad follow: valve oil, 5350 gallons; for internal lubrication of all steam valves and cylinders. Air-compressor cylinder oil, 150 gallons; for internal lubrication of air cylinders of all compressors, pneumatic hammers and drills. Marine-engine oil, 4175 gallons; for marine engines and block bearings of suction dredges. Stationary-engine oil, 2750 gallons; for general lubrication of stationary engines and machinery, electric motors and dynamos. Locomotive-engine oil, 3850 gallons; for all locomotives, running gears of locomotive cranes, deck machinery of dredges and for cold saws in machine shops. Turbine-engine oil, 400 gallons; for the step bearings of turbine engines in electric plants. Gas-engine oil, 150 gallons; for the cylinders of internal-combustion engines. Crank-case oil, 100 gallons; for crank cases of Westinghouse vertical compound engines. Car oil, 5175 gallons; by the electrical division for the generally, steam-shovel bearings, tripod drills, etc. Transformer oil, 200 gallons; by the electrical divisions for the oil-cooled transformers. Lard oil, 50 gallons; various uses. Ammonia cylinder oil, 50 gallons; for internal lubrication of ammonia compressor cylinders. Crude oil, 1000 gallons; for steam-shovel chains and special designated uses. Kerosene oil, 10,000 gallons; for illuminating and cleaning purposes. Signal oil, 100 gallons; in railroad lanterns and cab lamps of engines.

Gasolene, 3350 gallons; for motor cars, launches, blow torches, cleaning, etc. Nonliquid oil, 1850 pounds; used on Gatun cableways and air cylinders. Cup grease, 6000 pounds; for use in compression cups. Gear grease, 6175 pounds; on gears, center and side bearings, etc. Cable grease, 1000 pounds; used on Gatun cableways. Crank-pin grease, 40 pounds; on locomotive crank pins where equipped for its use.

METHOD OF HANDLING

All lubricants and oils are received at the general storehouse located at Mount Hope, and from there are distributed to the division storehouses, including the Panama railroad and the 10 outlying depots, from which points they are supplied to the local oil houses, situated at places convenient to the work, whence they are issued in daily, weekly or monthly quantities, as requisitioned on oil tickets, by employees in charge of the equipment or plant. Oils are delivered to the local oil houses in 50-gallon drums, which are used as containers by the insertion of a faucet, and have a value to the commission when returned to the contractor in good order.

All equipment and plants of the commission and the Panama railroad are placed on a monthly allowance, according to the necessities and nature of the work performed. A monthly report is required of the consumption of each indivdual piece of equipment and plant, which shows service days, and a satisfactory explanation of amounts used in excess of the monthly allowance must be made.

Monthly reports are posted at different places for the information of all concerned. All equipment and plants are furnished with standard oiling equipment and are kept in good repair, and are supplied also with containers for oil drawn for future use.

Oiling systems and drip pans are installed where required, and where sufficient quantities of oil can be reclaimed, filters are furnished. When the reclaiming of oils through drip pans is not sufficient to warrant the installation of a filter, oil is filtered at a central station for re-use. Careful attention is given to every detail of the work in regard to the issuing, handling and consumption of lubricants and oils, and instructions have been issued with reference to economy.

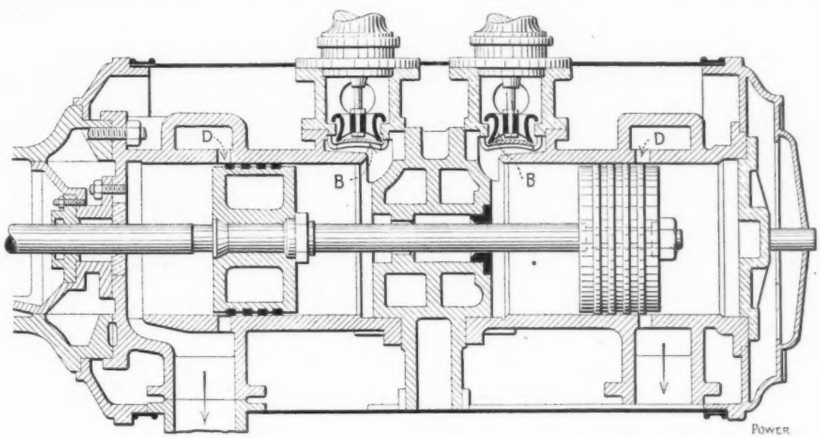
New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Double Piston Unidirectional Flow Engine

One of the principal advantages of the direct-flow steam engine of Professor Stumpf is that the variations of temperature of the metallic cylinder walls with which the steam finds itself in contact during expansion are reduced to a minimum and consequently the exchanges of heat between the steam and these walls, the losses of heat and the internal condensation. It will be noticed that in the single-piston engine designed by Professor Stumpf there are two surfaces by which considerable heat may be dispersed. These are the two cylinder heads.

In the model constructed by Kuhnle, Kopp & Kausch, of Frankenthal (Palatinsk), this is avoided. A partition with a stuffing box through which the common rod carrying two pistons passes divides the cylinder into two equal parts. The steam-inlet valves are arranged near the middle of the cylinders as shown at *B*. The exhaust escapes through the openings at *D*, which are uncovered at the end of the stroke.



UNIDIRECTIONAL FLOW ENGINE

As will be readily seen in this model, the loss resulting from the contact of the steam with the cylinder heads is much reduced. As to the outer ends, an auxiliary exhaust port keeps them constantly in contact with steam of the condenser pressure, with the result that the difference between their temperature and that of the surrounding air is relatively small. The disadvantages of the system would appear to be a more complicated construction than that of the Stumpf, and the difficulty of access of the stuffing box in the central partition. On the other hand, the conditions of the exterior stuffing boxes are improved since they have to resist only low temperatures and pressures.,

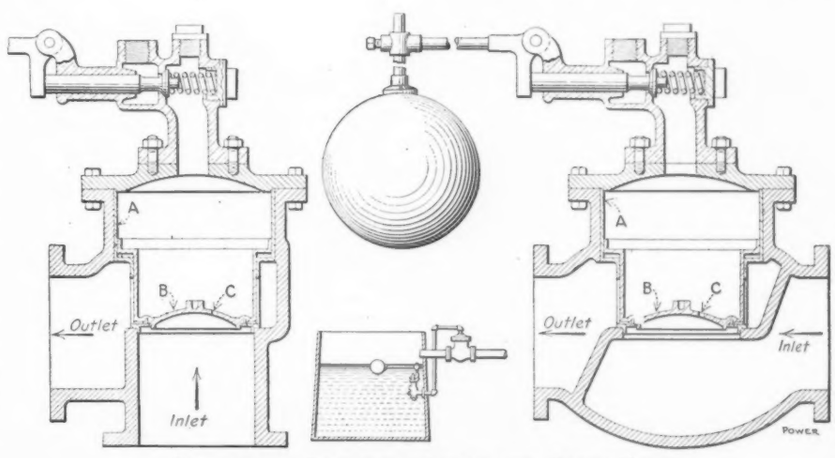
Automatic Cushioned Angle and Globe Valve

The automatic cushioned angle and globe valves shown in the accompanying illustration are lined with a bronze bushing *A* made in one casting down to and including the seat. The piston or valve *B* is of bronze and is fitted with a rubber, leather or lead disk, according to the service required.

The water coming under the piston or valve *B* also enters through port *C* on top of the valve, owing to the greater area above the valve *B* for building up the head pressure according to the size of the valve.

A pilot valve with a copper float attached is fitted to the top, or this pilot valve can be detached and placed at any distance desired. When the water in the tank reaches the required hight, the copper float allows the pilot valve to close, and the pressure builds up above the piston *B*, forcing it to close and shut off the flow of water through the valve. Water withdrawn from the tank or heater permits the float to drop, which opens the pilot valve, and allows the pressure above the piston to escape just enough to permit the flow of water to restore the required level in the tank.

These valves permit a small inflow of water or a large inflow of the full capacity of the pipe, according to the amount of water withdrawn from the tank. They are manufactured by the Golden-Anderson Valve Specialty Company, Fulton building, Pittsburg, Penn.



SECTIONS OF CUSHIONED ANGLE AND GLOBE VALVE

Triple Sheet Packing

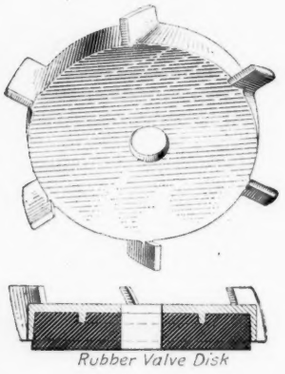
A new sheet packing has recently been gotten out by the Gutta Percha and Rubber Manufacturing Company, 126 Duane street, New York City. It is made up of three sheets comprising a hard black-rubber sheet between two sheets of red-rubber compound. It is designed with the idea of producing a strong, tough packing which will be tight and remain

permanent in the joints no matter how rough the surface of the flanges may be. It is said that it is not affected by expansion and contraction of the piping, and that it will not crawl but will remain in place after being inserted between the joints. It is suitable for use with steam, hot or cold water, air, gas, ammonia and for other uses.

Cooley Valve Rotor

This little device, illustrated herewith, has been designed to fit over a pump valve tight enough to slightly rotate it when water is discharged through the valve seat.

This rotating cap is fitted with wings which are cast slantwise to the outside edge of the cap. When the pump plunger



COOLEY VALVE ROTOR

discharges water it strikes the projections and the valve is turned slightly. This rotating motion is supposed to keep the face of the valve true and prevent leakage.

The device is manufactured by Cooley & Milligan, 320 Ford building, Detroit, Mich.

A Large Pumping Outfit for Mine Drainage

The El Oro (Mex.) Mining and Railway Company has just installed one of the largest motor-driven pump equipments ever built for unwatering a mine. The pump, which was built by the Goulds Manufacturing Company, Seneca Falls, N. Y., has cylinders 6x20 inches and a capacity of 500 gallons per minute. The construction is such that the pump can be readily dismantled and lowered down an ordinary mine shaft and when assembled it requires very little head room. The motor to drive the pump is a 200-horsepower three-phase machine of Westinghouse make. It drives the pump through double-reduction gearing, giving the crank shaft of the pump a speed of 35 revolutions per minute. The equipment is installed in the bottom of the mine and pumps against a head of 1300 feet.

This installation affords an excellent illustration of the advantages of the electrically driven pump in mine service. The flexibility of the equipment permits it to be installed and operated in almost any location.

Fatal Boiler Accident on Torpedo Boat

On October 23, a water tender was killed and a fireman badly scalded when two boiler tubes blew out on the United States torpedo boat "Tingey," off Charleston, S. C. The accident is the second of the sort within a period of four days, the "Wilke's" boiler tubes being blown out on October 19.

NEW PUBLICATIONS

Bulletin 49 of the engineering-experiment station of the University of Illinois, "Tests of Nickel-steel Riveted Joints," by A. N. Talbot and H. F. Moore, describes tests of riveted joints of nickel steel in tension and in alternated tension and compression. The slip of rivets and the strength of joints were determined. From the tests, the general conclusion is drawn that in riveted joints, designed on the basis of ultimate strength, the use of nickel steel may be of advantage; but that in riveted joints designed on the basis of frictional hold of rivets, while it may be advantageous to use nickel steel for the plates, rivets of ordinary steel seem to resist slip as well as rivets of nickel steel. Free copies of this bulletin may be had by writing to W. F. M. Goss, University of Illinois, Urbana, Ill.

SOCIETY NOTE

The educational committee of the Institute of Operating Engineers is at work on the lesson papers to be used in the various years' studies by those who intend to follow the courses of the Institute. These courses have recently been adopted in Armour and Lewis Institutes, of Chicago, and the Y. M. C. A's. of New York City, Buffalo and Denver. The educational bulletin, giving the facilities for securing the courses in the several cities, is ready and may be secured by application to the secretary of the Institute, Hubert E. Collins, Engineering Societies building, West Thirty-ninth street, New York City.

OBITUARY

At the instant of going to press we learn of the death of Robert Mather, chairman of the board of directors of the Westinghouse Electric and Manufacturing Company.

How Fireman Grimaldi Lost His Job

BY H. E. HOPKINS

Dat luck wat I hev' make-a me seek!
It jump' upon me mooch-a too queek.
Jus' wen I sen' for da famb' to come—
An' buy me da home in da Hail Columb',
For Rosie, an' Joe, Giovanni, an' Mick—
Da beeg-a boss say: "Get out, d—— quick!"

Pietro Michaelo Grimaldi's my nam',
An' wen to da lan' of da free I cam'
I buy da banan' an push-a da cart
An' make-a mooch soldi right from da start.
But dat is no kin' of a beeziness—
I work day an' night 'an' get-a no res'.

So a fren' of mine from da ol' countree
Say he know a job dat'll jus' suit me:
"Dey want a good man at da power-house;
Bright, steady man—no wat you call 'souse.'
Wide in de should', an' strong in da muse',
One of dose wops dat is mooch-a da husk'."

He tak' me roun' to da engineer
An' say to heem: "Pietro is here."
Dat boss say: "Alright!"—like-a dis—
"You jus' da man for dis beeziness.
I need a feller wat I can trust
To keep dese boilers from makin' da bust.

You 'tend to your work de bes' wat you know
An' you'll get fine wage"—wat you call dough.
All da day long da fires me stoke
An' deeg-a da clink' wid da long poke'.
I hoe out da ash' into da pile—
It make-a da heap one, two, t'ree mile!

I shov' da coal 'till I'm red in my face;
Make-a me feel— Wat you call dat hot place?
I watch-a da gage an' da indicat'—
"Sapristi!" dat boss say: "You is firs' rate!"
'Twas den I was feelin' beeg by da chest,
I could sen' for my Rose, Mike an' da rest!

So I shov' an' poke. As da clink' I loose
I seeng out my t'roat jus' like-a Carus'.
But—one day dis countryman fren' of mine
Makes in a letter dis mooch-a bad line:
"I got you dis job: now, you'll hev' to pay
One 'undred soldi by nex' Thursday!"

He tink I mus' be Giovan' Rockfellar,
Wid mooch-a da mon' heap' up in da cellar!
"Sapristi!" I say, "You try to do me?
No! dis' is da countree wat is call' free.
Take it some straight from Meester Grimaldi;
'Tis Rosie's bambinos gets da soldi!"

"I feex it for you; I make-a vendett',"
Say Toni to me; "I get-a you yet!"
He swell heemself up jus' lik' a boiler
Till heem look mooch as a lobster broiler.
"I get da revenge!" cry Toni to me,
An' I tell heem go chase; hully da gee!

I was hoping some day to get da lic',
An' hev' in my home everyt'ing nice,
An' giv' da bambinos mooch educat'—
But becaus' dis Toni did me so hate,
Heem sneak in da fire room—lay me out flat
Wid da beeg blow jus' back of my hat!

Den I know not'ing for six-a week quite
For my head did dijes' too mooch daylight.
An' wen I go back to dat firin' shop
Da boss heem had hired anoder strong wop.
Heem tell me lik' dis: "Too mooch-a fight.
No good for da fire. Out of my sight!"

An' dis is da why dat luck mak' me sick!
P'raps I go get-a da shov' an' da pick:
Mebbe I 'list in da White-a da Wing.
I mus' mak' a liv' by doing somet'ing—
Sapristi! I'll be one gran' poleetician:
Mak' plenta mon'—don' need da poseetion!

$45 to $300 a Month

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Mr. O. J. Gibboney, Erecting Engineer, No. 3 Niagara Square, Buffalo, N.Y., who is now engaged in a responsible position in the erecting engineering field writes us under date of August 1, 1910, as follows:

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"In the meantime I continued with my studies, completed my Course and received my diploma January 6, 1909, with a very creditable average of 99⅔ per cent. on the complete Course.

"In October, 1909, I again accepted a position netting me $175 a month, and on June 1, 1910, my salary was increased to $300 a month—about 550 per cent. more than the salary I received when first taking up my Course.

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Electrical Engineer	Machinist	Assayer
Electrical Mach. Des.	Toolmaking	Bookkeeper
Dynamo Foreman	Molding	Civil Service Exams.
Electric Lighting	Blacksmithing	Commercial Law
Electric Railways	Civil Engineer	Architecture
Electrician	Gas Engineer	Contracting & Build'g
Telephone Expert	Refrigeration Eng.	Automobile Running

*Name*_____

*Street & No.*_____

*City*_____ *State*_____

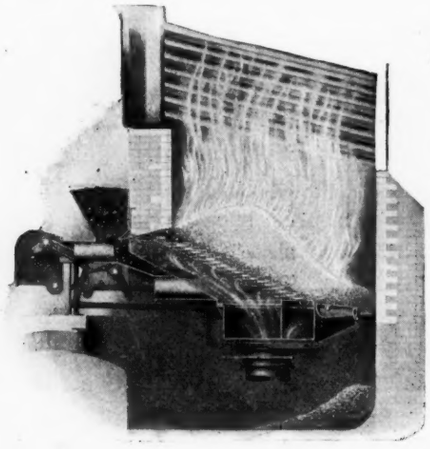
*Present Occupation*_____

NEXT MONTH

when you are working your boiler fires for all they are worth and trembling for fear of a visit from the smoke inspector

REMEMBER

that it isn't the fault of your boilers —the furnaces simply can't burn enough coal.



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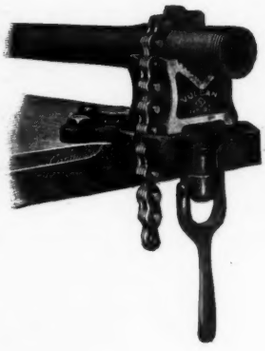

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